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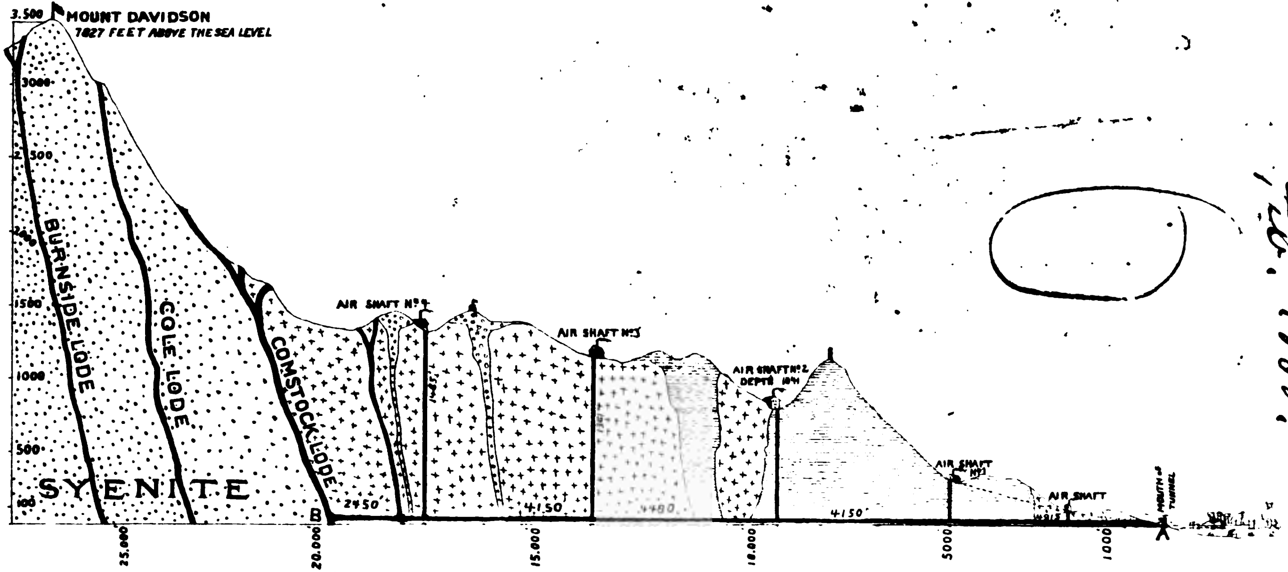

A distorted, and somewhat hypothetical, profile section of Mount Davidson, the Comstock, and the various overlying frontier formations of mixed feldspathic country rocks, as penetrated by the "Sutro Tunnel," and its ventilation shafts.

THE

EXPLORERS' AND ASSAYERS' COMPANION:

ROCKS, VEINS, TESTING AND ASSAYING.

VOLUME I,
(Complete in itself,)
OF THE
THIRD EDITION
OF
"Explorers', Miners' and Metallurgists' Companion."

A PRACTICAL EXPOSITION OF THE VARIOUS DEPARTMENTS OF GEOLOGY, EXPLORATION,
MINING, ENGINEERING, ASSAYING AND METALLURGY.

By J. S. PHILLIPS, M. E.

VOLUME II,
"MINING AND METALLURGY,"
WILL FINISH THE WORK.

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INTRODUCTION.

TO THE PROSPECTORS, MINERS, METALLURGISTS, AND MINING CAPITALISTS, OF THE UNITED STATES OF AMERICA, AND THE BRITISH COLONIES.

The first and second editions of this work having been written for, and dedicated to you, I again take pleasure in laying this, carefully revised, Third Edition, before you, with the hope that it will obtain equally favorable approval.

No subject can be selected where a really practical book is so much needed as in the varied fields of mining, for the assistance of those who have not been educated to this work, as more knowledge of the several trades and professions is required in the development of mines than for any other business.

The worst mistakes of young miners have occurred for want of ordinary prudence, in this unusually difficult occupation. Instead of employing men with practical ability and experience, interloping clean-fingered theorists have been much favored, who having discarded real mining, from deficiency of skill in that department, have played recklessly with new ideas of metallurgy, or worked prematurely where insufficient mineral existed, and far too often, not only wasted your last dollar, by such haste and ignorance, but inflicted severe retardation to systematic mining.

It may be loudly reiterated for everlasting advantage, that reduction works should not *precede*, but *succeed*, the discovery and exposition, by mining, of *sufficiently rich and extensive deposits* of mineral for *positive realization of profits*. If you have no corn, why the mill? First obtain wheat, then grind into flour.

Constant care should be taken lest you run into such preliminary errors, and to greatly assist in these examinations, a few pages were introduced into the first edition to describe and explain the capabilities of the "Prospector's Wee Pet"—an automatic assaying machine—and because of its great value in testing, they are now reprinted. This apparatus was especially contrived for, and dedicated to, Explorers, whom I admire for their indomitable energy, self-sacrifice and bravery, more than any other class engaged in the industrial pursuits; but it will also ascertain the value of rock for all practical working purposes—not strictly commercial—throughout the departments of mining and metallurgy.

Having a knowledge of all the other methods for assaying, and their comparative uselessness for the *mountain purposes* of the novice, I have contrived this machine as the ever ready means for elevating ordinary men, after a few hours instruction, to the level of the expert, by any other method, for such itinerant purposes; and the whole apparatus, with tools, fluxes, calculating strips, weighing and calculating lever, moulds, etc., of about seven pounds weight, may be packed for travelling within a cube of five inches. As the cost for making an assay for gold, silver, copper or lead does not exceed ten cents, such men may actually make thousands of assays which could not be otherwise afforded, or accomplished. The single critic who found fault that a few pages out of 672 had been used to describe this useful machine, because it was the invention of the author, gave it superlative praise in the same breath, and therefore showed an insufficient reason for excluding its advantages from the world.

"The Vest Pocket Blow-pipe," and "Little Wonder;" the "Pocket Laboratory," and "Tester," have been more recently invented and are herein described.

The original intention was to write a small Prospectors' pocket guide, with instructions for preventing such disastrous initial mistakes and final losses; but the work has been greatly extended, to embrace the whole field of mining, which with so many blanks around the prize, is sufficiently hazardous at best, to bear such unnecessary errors from insufficient examination. A retrospection of the past will show that hundreds of mills and other reduction works have been erected, as enormously expensive assaying machines, but to thus subsequently prove, what should have been known, that the veins were worthless.

This work has been more especially framed for uneducated practicals, to benefit them and mining, by treating of such subjects and mineral combinations as will fall within their sphere of action, and therefore plain terms have excluded the stereotyped phrases of books for such men's "living present" requirements.

The geological chapters are somewhat speculative and written more for the miner, who should understand the nature of rocks relative positions of minerals, than for conformity with what een termed geological accuracy, so as to give more practical of the various formations.

Some hard criticisms were expected, and one or two received, for these bold innovations, but as I believed in their solid basis they were printed, and it is now very gratifying to see that exactly similar fundamental principles to my "whimsical ideas" and "absurd notions" then published, in reference to the sinking of the valleys, side compression, &c., have been since promulgated by Mr. Robert Mallet, F. R. S., the celebrated seismologist, and which have been more approved by scientists throughout the world, than any of the old theories.* ‡

See pages 70, 71, 72, etc., in First and Second Editions; pages 85 and 86, and Foot notes at pages 115 and 118, in this Edition; for priority of idea, against a recent paper read before the Geological Society of London, about hot water bringing minerals from great depths to deposit in the more shallow and colder sections of veins, and even upon the surface.

It may be here stated that up to 1869, the time the many theories of this book were first printed, I had only studied Sir Charles Lyell's geology, and therefore any novelties found herein were procured from independent and close observations of the illustrations in the voluminous folds of Nature's Free Library; wherein I read that "*Lateral pressure,*" caused by the *irregular settling* of the earth's shell, as urged by gravitation, had formed the mountains by thickening the crust; the ocean beds by quicker subsidence, had fractured the veins, by leverage; and caused metamorphic effects upon sedimentary rocks and perhaps on even the mountain granites, by such inconceivably enormous pressure and consequent motion, friction and heat, which will also account for volcanic heat and force, tidal waves at the borders of oceans, and favor my theories for earthquakes, &c., as explained in Chapters I, II, III, and V. The unacknowledged repetitions of many of these notions by a local author on geology, will be sufficiently exposed by ten years difference of dates, as these and the many other novelties, too numerous for mention here, were also published in the First and Second Editions.

Dana says, in his Geology, that the drawing down of some parts may have produced *tension* and *bulged* other portions of the surface, but nothing is said of either lateral pressure and consequent crushing, thickening, &c., or of my several other theories, so especially linked therewith, and the causes for and reasons why these astounding results have been produced.

---

* Several other quotations might be given in support of the view that Mr. Mallet has been anticipated by Mr. Phillips, but the above will suffice to show that the theory is not so new as Mr. Mallet has supposed.—*Mining Journal, London.*

‡ Many other passages might be quoted to more fully establish the fact of priority (for Mr. Phillips) as above, in setting forth the "new theory" of mountain formations.—*Mining and Scientific Press, San Francisco.*

The chapters on the comportment peculiarities and indicative features of mineral veins, are derived from long observation, and it is hoped that they will not only afford some records of value to the amateur, but be interesting to scientists and every class of thoughtful miners.

The section on exploration, the miner's first and most important duty, which governs after success or ruin, has been as carefully considered and safely advised.

The chapters on the discrimination and assay of minerals have been kept as free from formulæ as possible, and not only contain the best of the old modes, but many novel and more available methods for practical men, so that when the one facility is absent, another will be found present, to suit all the requirements of the mine, the roasting furnace, the mill, the smelting and chloridizing works, and the mountain; whilst in that, for the strictly commercial purpose, the more direct, less mystified, and least dangerous means and fluxes have been selected.

The new modes for assaying gold, silver, and lead, page 208; the testing for the useful minerals by a direct and simple blowpipe method, page 203; the Alphabetical Chapter for general discriminations, page 213; the several useful tables, and the Glossary at the end of this Volume, will supply additional helps to amateurs.

To favor the convenience of Prospectors, this, Volume I, the "Explorers' and Assayers' Companion," will be sold as a separate book, of either *pocket or library size,* and only treat of Rocks, Veins, Testing and Assaying.

Volume II, the "Miners' and Metallurgists' Companion," will also be complete in itself and finish the whole work by an exposition of Mining and Metallurgy, which will probably increase the combined size to about 1,000 pages.

Many books have been written on metallurgy, and very few on mining, which are but theoretical, confined to one subject, or more of a general, historically interesting, or statistical import, an of practical value for miners. In such works little has been id of the peculiar geology of mineral-bearing rocks, or of the dicative features of mineralized sections, less of the underground operations of mining, and nothing of that most imperative and effective lever, its mechanical engineering, either above, or below, the surface.

This was written to fill these blanks, to meet the requirements of new countries, and therefore, in many instances, entirely new ground has been trailed, and departments explained which have not been previously exposed by less practical writers. The constant aim has been to aid legitimate mining in every useful way, so that only the few really necessary and best means, methods, machines, and processes, have been selected; instead of giving more elaborate, costly and confusing, descriptions of all.

In mining and engineering the best plans of operation and machines have been extolled, and the most common errors of the past exposed as beacons for avoidance.

In the metallurgy of this volume just sufficient has been selected from the most valuable and best established processes for rendering the ores of remote countries more marketable, by crushing, pulverizing, concentrating, roasting, milling, smelting, refining, chloridizing, and chemical reductions.

The First Edition was written in eight months, during business hours, under most unfavorable circumstances, and having been printed from the original manuscript, showed signs of haste with many imperfections of language; the Second Edition was so quickly required, that, to reduce the price of the book, many of the old forms of type were retained; but now, this, much enlarged, Third Edition has been thoroughly revised and will much better deserve a continuance of the public's appreciation.

In this exposition of a life's experience, my constant aim has been to render the work interesting and valuable to *practical men and capitalists*, and if at times, in the necessary enumeration of past errors, the lash should be individually felt, it was really intended for the general benefit of miners, so that *legitimate mining* may entice more attention and obtain much more abundant success, in the future.

Yours, respectfully,

San Francisco, 1878. THE AUTHOR.

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SECTION I.

GEOLOGY AND MINERALOGY.

CHAPTER I.

FORMATION OF THE EARTH FROM ITS INITIAL CHAOTIC STATE TO THE SOLIDIFICATION OF ITS PRIMITIVE SURFACE AND GRANITE MOUNTAINS.

> **"In the beginning God created the Heaven and the Earth.**
> **"And the Earth was without form and void."**
> ***Genesis*, chap. 1, verses 1, 2.**

As a work on mining would be incomplete without some observations on the general features and ages of rocks, three chapters have been introduced to describe the primitive, the azoic, and paleozoic formations.

Theory has not thus far, and probably never will be, of much direct benefit to the matter-of-fact miner, for metallic minerals, who reads the more tangible indicative records, which are unfolded during a life's experience, by shafts and levels of exploration in his *individual* district, of mineral ground. The following is written with full knowledge of these facts, first, for his amusement; and secondly, to enable those who have not been favored by a long experience to know what is meant by the terms so frequently alluded to in this book—*primitive* and *secondary rock formations from primitive elements*, prior to the fossiliferous mud stratifications of after times, which contain but comparatively few of the metallic minerals in sufficient quantities to pay the costs for mining.

The theory advocated by Laplace, that all matter was once in a gaseous state, would infer high temperature and freedom from pressure, with the presence of some other controlling power, unknown to science, to prevent the general solidification into but one central mass, instead of the innumerable spheres with self-rotations and orbitual motions, as accompanied by their satellites, they traverse through the various portions of space.

It will be sufficient for our purpose to accept it from the Creator, as hurled from the sun or other source, a ponderable nucleus, enclosed by its adhering molten envelope, and surrounded by the nebulæ and gaseous elements which were collected and retained by gravitation, when tangentially projected, to traverse in an annual orbit around the sun, at a distance governed by its speed, etc., whilst it would continue to revolve around its own axis, as it did when first projected: other discharges may have succeeded from similar causes, which, partaking of corresponding direction and force, would arrive within the annular orbit of the Earth, and be attracted by the larger body already performing its destined course, and aggregate—by the retardation and acceleration of the anterior and posterior particles of this nebulous ring—into a continually increasing mass.

After billions of years had passed away, when the lighter granitic exterior of the earth became from molten to plastic and partially solid condition, we will consider what actions must have taken place in reference to the general contractions that produced the irregular contour of surface and subterranean cavities. Previous to this it may be safely supposed that the surface of the earth was a regularly shaped and comparatively smooth globe, surcharged and enclosed with oxygen, hydrogen, and other inflammable gases or substances, and being largely fluxed with potash, soda, lithia, lime, magnesia, sulphur, iron, manganese, etc., it must have possessed a well fused molten envelope of granitic slag and surface dross. Until this settled almost to solid rock, it would be drawn by contraction and gravitation directly downwards in close contact to the still molten interior, but at a certain stage of solidification, because it naturally contracted less in cooling, than the next interior, hotter mass, this vertical action of the *outer crust* would almost cease, when the contraction of the *warmer interior*, being further accelerated by the evulsion of gaseous elements from the molten state, immensely extensive subterraneous cavities would be formed under the superimposed spherical segment of granitic crust; which then, partaking of *lateral thrust*, by solidity, the abutments of these vast arches would give way, under the increased pressure, and consequently more plastic condition, and the crust would thicken into mountains at the lines of greatest pressure, where the endurance of the rock was exceeded; or valleys and extensive plains sink, by mere straightening, as the ocean beds, to rest at certain places upon the interior, until a repetition ensued.

After the period of the first distortion, the portions forming the present ocean beds, having commenced deviation from spheroidal form, would hasten to approach straight lines or planes from gravitation alone, and the enormous weight of such portions of crust as the Pacific, Atlantic, and Indian Ocean beds, by acting transversely, with irresistible power, being spheroidal and solid, could do no less than thicken more mountains in a similar manner, for *side room*, and from central contractions and weight, cause the simultaneous depression of plains. This principle of force seems substantiated by the facts that the highest mountains form the borders to the widest oceans all over the world, and the average heights opposite each ocean appear to bear corresponding ratios thereto. This may account for the first ocean beds or basins, but I think the chief cause for the modern *volcanic mountains* bordering oceans is, that the gaseous forces have been generally insufficient for mastering the cooling influence of such a vast quantity of water, therefore the escapements took place beyond the shores, and built comformable ranges of mountains.

In later times, towards the end of the second, and on to the middle of the third chapter, the principles of downward action of gases and liquids, and transferrence of sensible heat of steam into the latent heat of water, would by this disappearance of sensible heat, greatly assist to weigh and cool down these unsupported solid portions, and still continue to straighten the bottom from a spheroidal form towards that of a plane; whilst the mountains would not be thus refrigerated, and, from their comparatively insignificant areas and weights, they would be retarded in downward travel. If the ocean beds merely sunk but one hundred yards, the whole of the lower portions of the paleozoic formations of the continents would appear as now. These effects may apply to deeper strata in the interior of the earth, so far as contractive pressure and temperature are concerned, and as the earth continued its cooling, other internal hollow globes or spherical sections would in like manner be forming from plastic to solid states, which, when compressing laterally as described in the crumpling of surface mountains, the portions, where internal mountains were forming, would be crumbled and suddenly forced upwards under the outer shell, whilst the adjoining still solid portions would—by consequent circumferential motion—rub violently against the interior of the more stable outer shell, and produce such motions as earthquakes, a greater degree of heat, and force the pent-up molten matter and gaseous elements discharge through surface volcanoes. Whether this is a true or false theory, it is a fact that granite shrinks much less than most other materials, and as all varieties of matter contract differently, as a rule, the heaviest the most, it follows that the solid portions of the interior must frequently have very large caverns, more particularly under the outer crust; and where the molten state commences, the oxides or chlorides, etc., of the metals may intervene in immense chambers.*

This removes the difficulty of finding materials of suitable weight to equal the calculated *average* specific gravity that the earth should possess, and will serve for reference to explain many things which will be considered in the chapter on the formation of mineral veins, etc.

If it be admitted that cooling *commenced at the surface*, from *radiation*, or transferrence of *sensible* heat into *latent insensible forms*, by chemical compositions or gaseous elements into liquid and solid forms, or from any other causes, it must follow that this theory of contraction is true; for after the surface became sufficiently cold for solidification and cessation of shrinkage, it would be absurd to say that an interior molten globe, of nearly 8,000 miles in diameter, would cease to contract within the more fully contracted and colder, solid shell, the more so because of the continual evulsions of gaseous elements through volcanoes, from decomposition of the fluids of the interior.

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*The roofs of these extensive caverns are not likely to be of regular form, but are probably very stalactitic, having large, acute angled inverted hills, which being occasionally struck on their different slopes by the discharged matter from the subterranean volcanoes, described in Chapter IV, on earthquakes, they would not only afford the means of propagating the waves in different directions, as governed by the side smitten, but vary the effects, and produce much greater disturbance at the surface.

It now becomes my interesting and important duty to notice the peculiarities and component parts of the various granitic rocks, herein denominated, for the miner's purpose, primitive formations.

True granite is composed of quartz, feldspar and mica; the feldspar and mica are disseminated as separate crystals in the quartz (which latter but fills the intervening space) to form a very regularly speckled rock, so differing from all others of a sedimentary or artificial nature that it must have been first fused with soda or potash to a fluid, and the feldspar and mica have then aggregated and crystallized, under the succeeding appropriate affinities, which were eliminated at certain suitable temperatures during the slow refrigeration of the globe, whilst the surplus silicic acid must have gradually solidified to fill the remaining irregularly formed interstices.

On referring to the Elementary Treatise on Mineralogy by William Phillips, to whom I am indebted for many other compositions of the minerals, as analyzed by renowned chemists, I find that quartz (otherwise called silica, silicic acid and oxide of silicium) is composed of oxygen 51.95, and silicium 48.05; feldspar, from a comparatively pure specimen, analyzed by Berthier, 64.2 of silica, 16.95 of potash, and 18.4 of alumina. The most simple specimen of mica that has been recorded is that from Brunswick, Maine, analyzed by Thompson, which was composed of 64.44 of silica, 28.84 alumina, 4.4 protoxide of iron, and 1 of water. These constitute granite proper, with the three imperative ingredients comparatively pure; but there are several species of variously colored and constituted granitic rocks, that are also primitive when viewed from the miner's standpoint, which have not only slightly different arrangement of parts, but partake of a great variety of chemical as well as chance mixtures. See chapter on the alphabetically arranged list of minerals, for better recognition of component parts, and to the following quotation from Dana, for descriptions of the granites:

GRANITE.—SYENITE.

"*Granite* consists of the three minerals, quartz, feldspar and mica. It has a crystalline granular structure, and usually a grayish-white, gray, or flesh-red color, the shade varying with the color of the constituent minerals. When it contains hornblende in place of mica, it is called *syenite;* hornblende resembles mica in these rocks, but the laminæ separate much less easily, and are brittle.

Granite is said to be *micaceous*, *feldspathic*, or *quartsose*, according as the *mica*, *feldspar*, or *quartz* predominates.

It is called *porphyritic* granite, when the feldspar is in large crystals, and appears over a worn surface like thickly scattered white blotches, often rectangular in shape.

Graphic granite has the appearance of small oriental characters over the surface, owing to the angular arrangement of the quartz in the feldspar, or of the feldspar in the quartz.

When the mica of the granite is wanting, it is then a granular mixture of feldspar and quartz, called *granulite* or *leptynite*.

When the feldspar is replaced by albite, it is called *albite* granite. The albite is usually white, but otherwise resembles feldspar. When replaced by talc, it is called *protogine*.

Diorite is a rock of the granitic series, consisting of hornblende and feldspar. Color dark green or greenish-black. Crystalline texture distinct.

GNEISS.

Gneiss has the same constitution as granite, but the mica is more in layers, and the rock has therefore a stratified appearance." *

All may contain oxide of iron, or manganese, whilst the feldspars of different varieties often contain, in addition to silica, potash and alumina, also soda, lithia, magnesia, lime, oxides of manganese, and iron; and mica, in addition to silica and alumina, the oxides of iron and manganese, potash, soda, lithia, lime, fluoric acid, and water.

These are, therefore, in their more simple and imperative forms, silicates of potash and alumina; the oxides of iron and manganese being present, from their universal prevalence in nature rather than a chemical necessity for their constitutions; they have, however, considerable coloring properties, whilst the others are indifferent mixtures, happening to be present in such localities during fusion. 977-thousandths of the rocks are composed of oxygen, silicon, aluminium, potassium, sodium, lithium, calcium, magnesium, iron, manganese, and carbon. Primitive rocks contain all but the last, which fire expelled, and which, with hydrogen, chlorine, fluorine, nitrogen, sulphur, boron, and barium, almost complete the after rock formations.

The constitution of these various granitic rocks expose seven exceedingly interesting and strikingly remarkable features.

First. The enormous quantity of this kind of formation.

Secondly. The amazing amount of solid fixed oxygen in the silica, and silicates, constituting nearly half the weight.

Thirdly. The oxygen is separately combined, in direct or acid forms, with all these minerals.

Fourthly. Oxygen and metallic minerals are alone present.

Fifthly. These minerals are all very difficult to be reduced to the metallic state.

Sixthly. The very lightest metallic elements are those contained in such surface rocks.

Seventhly. They are very stable during fusion.

Eighthly. The absence of all volatile carbonates, chlorides and sulphates of lime, magnesia, etc., etc.

These, combined with the following facts, substantiate at least the igneous *origin* of this Earth, which partakes of the exact mathematically calculated shape that a fluid of its specific gravity and size would have assumed, when rotated at the same speed (7,926 miles equatorial, and 7,899.507 miles of polar diameter), and that the temperature increases below the depth of the sun's influence, at the minimum rate of 1° for every 60 feet deeper throughout the whole world, which collectively prove that fire was the mighty subservient power used by the Creator to shape our terrestial globe. These are the local proofs.

To disbelieve in the agency of fire in the initial casting of the innumerable worlds of the vast universe, we must doubt and despise all the facts that are derived from observation, both here and in space; for chemistry, the eye, the telescope, and the spectrum, unfold continual proofs that innumerable spheres are now burning exactly similar elements to those of the Earth, where water itself must have been so formed, as the product of combustion of oxygen and hydrogen, whilst the Earth and its surface of "primitive" rocks were being fused by this consequently high temperature.

In connection with this theory it is difficult to understand why the gases, which are all so light, are immediately present with the much heavier molten or solid mass, for the continuation of combustion; and it appears from necessity that all the gases must have the property of becoming liquid or solid under extreme pressure, and may have lain in that original condition, and bursted forth as the pressure is by any means removed. It can be proven to be so in some instances, even under the moderate means we can command, whilst to reverse the action all the solids and fluids can be volatilized. A good illustration of this may be seen in mercury, for under a slight advance of the temperature of our atmosphere it would have been volatilized from its metallic states of fluidity and solidity, and be concealed forever from mankind.

If these rocks were thus formed at high temperatures, amazing quantities of their elements must have been at some period existing in a volatile condition, and if so the whole globe would have been surrounded by this very high, and consequently enormously heavy, elastic atmosphere of such, and the question arises whether the speckled crystallized ingredients of such rocks may not have been actually formed when these free elements were thus supported in this elastic medium, and gradually settled into their bed of silicic acid, just in similar manner to the snow of our much lighter atmosphere. The bed rocks being formed under their natural chemical affinities as the pressure and temperature decreased during exceedingly slow cooling; the snow by cold alone, whilst the principle of support applied alike to both.

During these formations, the earth's crust or hollow shell would continue to be violently compressed in circumferential directions, and being solid it would, from its own gravitation, as it endeavored to follow the still faster contracting interior, crumple and distort certain sections of least resistance into extensive ocean beds and the comparative elevations with rolling surface contour of hill and dale.

In such a state of homogeneity or equality, the partial invasion of volcanic fires had not at this early period *really uplifted* any mountains; but their apparent elevations existed more from the above causes, and a difference of subsidence or *loitering behind* of such portions, during the *general travel,* when urged by contraction and gravitation *towards the center* of the earth.

To make the preceding principle of action still more intelligible, it may be supposed that the whole exterior solid and colder shell of the earth has been continually urged downwards by its own unsupported weight, after the hotter and faster contracting interior, and therefore when any large subterranean space has been formed, that portion which lies above will endeavor to slide down, or settle thereon, and as soon as this sufficient hollow area creates an ample power from gravitation to crush the necessary side room, by thickening that particular part of the adjoining surface into mountains, this immensely heavy dome of crust being thus released will be thereby allowed to force its way and shift down upon its underlying region. It is not at all plausible that the whole crust has at any time descended in the one operation, so that these hollows of power have acted everywhere separately at different times, and caused innumerable and most irregular settlings both of mountains and ocean beds; but the latter having been forwarded at the commencement, have generally kept a leading position since.

This lateral crushing is imperative, for unless the size of the shell is reduced to that of its enclosed faster contracting contents, it cannot fall to rest thereon.

At this stage of the creation the whole surface would be more or less covered with the deep oxidized dross from a world's fusion, which would be largely composed of soluble soda, lime, magnesia, etc., and all other substances that were either in excess or lacked the necessary affinity for uniting with other constituents which formed the solid *primitive* mountains, and "bottom" of *granitic* "*bed rocks.*"

This would be encompassed by a ponderous mixed atmosphere, composed of all the vapors and gases that fire could create, volatilize, or release, and which were in excess or unnecessary for the compositions of these *primitive* corrugations of the "bottom rock."*

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*In favoring these theories for primitive formations, I would not be misunderstood by religious people, as I am neither atheist nor infidel; the sequence of creation as described in the first chapter of Genesis, conforms in general terms, so wonderfully close with scientific records, that the length of days is the only apparent absurdity, and this expression must have been merely figurative.

CHAPTER II.

FORMATION OF THE FIRST CLAY SLATES, GREENSTONES, AND THE VARIOUS FINE GRAINED HORNBLENDIC AND FELDSPATHIC MIXTURES, FROM PRIMITIVE ROCK ELEMENTS.

> "And darkness was upon the face of the deep."
> *Genesis*, chap. 1, verse 2.

Here commences an eon of the greatest possible confusion, when probably all the known gases and vapors that the chemical agency of fire could produce, from the but recently fused globe, existed as a voluminous, heavy and dark atmospheric envelope, over the incrustations of partially soluble dross, that covered the surface of the refrigerating, but still, red hot, earth.

Under such conditions, who can say what changes might not have been produced from this time until water ceased to boil, under the atmospheric pressure? The various crystalline rock formations, and the apparently extraordinary erodations of the general surface contour, would have been speedily accomplished, and many things, now unnatural, realized.

These principles of heat and pressure have not been sufficiently studied or experimented on by geologists; although they favor the molten and refrigeration theory, and consequently admit that such degrees of heat then existed, they and chemists, have neglected to examine what effects can be chemically produced by the gases, or the alkaline and alkaline earth solutions, under conditions that must have existed during this period.

Water, in vapor and liquid, has exerted more controlling influence, and wrought more variously in dissolving, decomposing, disintegrating and modifying the earth's surface, than all other vapors, gases, and liquids combined; and should, therefore, be more elaborately considered in reference to its peculiar characteristics and qualifications.

It appears to have been the most astounding conception of the Creator, an especial and universally pre-arranged provisional means for accomplishing, uniting, and sustaining all the necessary creations that were intended to be accomplished throughout organic and inorganic nature.

Without water, nothing could have been formed, nothing supported, or continued; it is not only a necessity for all creations and stages of animal and vegetable life, but also of inorganic crystallizations and constitutional forms. It would require volumes even to name the substances with which it is associated, and its many peculiarities; but the following may be profitably remembered.

Water is formed when hydrogen is kindled, either with flame or electric spark, in presence of free oxygen. It is colorless, tasteless, and inodorous. It does not change its state under ordinary circumstances, when free from foreign matter, in any way, during any length of time. It is indestructible, and is not, so far as yet ascertained, within moderate degrees, chemically decomposed by heat—for, although entirely vaporized, it returns, on cooling, to the liquid state, as before, *ad infinitum.* It combines in various forms of basic, hydratic, and saline water, as well as that of crystallization, with more elements than any other known liquid. It is perfectly neutral, possessing neither acid nor basic properties, yet unites with both, and increases their chemical activity. It also combines with neutral salts, in two conditions of crystallization.

Although it possesses neither acid nor alkaline strength, *more* substances are *soluble therein* than in any other liquid; which can be again separated by mere evaporation. The solvent power of *water on solids* is *generally increased by heat—lime* being one of the exceptions, where it is decreased. At the ordinary temperatures experimented on, magnesia is insoluble in water, although at higher degrees it may not be so. Heat diminishes the solvent power of water for gases, but increased pressure would, to a considerable extent, counteract this, and in some cases reduce gases to liquids, which would act differently. It partakes of the property of evaporating at ordinary temperatures into clouds that are sufficiently light to float as vapor in mid air, which by aggregation descends as rain, in wonderfully well regulated quantities. It is the only liquid that varies from the general law of expansion by heat, and contraction by cold; as it continues to contract down to 39° Fahrenheit, and then to expand again as the temperature decreases to the freezing point of 32°. Were this not so, the ocean would become one mass of ice from equator to pole, as the ice by freezing would continue to sink to the bottom until the whole mass became solid, when the sun, acting but on the equatorial surface, would possess but little power to thaw such a tremendous bulk, and the cold become so general that rains would be frozen into snows or hail-stones, and all organic nature perish—which is in itself an unmistakable Almighty provision for our safety. It is sufficiently buoyant, that land animals falling therein, may by proper exertion, save their lives. It is also of very suitable floatability and density for the ships of man, which he is enabled by skill to frame and build, but just strong enough to barely resist its momentous effects. Water boils at a degree but just sufficient to cook our food and freezes at a point that does not seriously interfere with our comfort or general operations. It is the only liquid that would suit the general requirements of the house, the chemist, miner, miller, and engineer, even if others existed in sufficient quantity. It is clean, clear, non-glutinous, is the exactly requisite specific gravity, and can be filtered, evaporated off, or condensed at pleasure. It contains considerably *more latent heat* than *any other* liquid.

When water is boiled in a close vessel over sufficient heat, the first temperature of the boiling point, in a vacuum under no pressure, is but 67 degrees, or 35 degrees above that of freezing; but as the pressure is increased by the formation of steam or by any other means, over the liquid, the temperature of the boiling point also increases with a comparative ratio, and the pressure being known, the temperature (which it invariably governs) may be calculated therefrom, or *vice versa*.

The boiling point, under but one atmosphere's pressure, equals, at the sea level, 212°; that is, 180° above the freezing point of 32°. The latent heat of water and steam is estimated at 1000° at the atmospheric pressure, and the sums of latent and sensible heats of water are always equal to 1180°, in a vacuum, under atmospheric or any other increased pressure, up to the limit of elasticity of steam; where all that is possible of the latent heat has been expelled into sensible form.

M. M. Dulong and Arago, under a commission from the

French Academy, have demonstrated, by actual experiments made, under pressures varying from 1 to 50 atmospheres, that the pressures and temperatures range as follows: Taking for our purpose the intermediate figures which stand opposite every advance of 5 atmospheres, and starting from the boiling point in vacuum, it reads thus:

Boiling point in vacuum under a pressure of	0	atmosphere	67°
" " " " "	5	"	307.5°
" " " " "	10	"	358.28°
" " " " "	15	"	392.46°
" " " " "	20	"	418.46°
" " " " "	25	"	439.34°
" " " " "	30	"	457.16°
" " " " "	35	"	472.73°
" " " " "	40	"	486.59°
" " " " "	45	"	499.14°
" " " " "	50	"	510.60°

So far we have thus well established these practical steps in a series commencing with the sums of 67° sensible heat, and 1113° of latent heat, which=1180°, and ending with the *sensible heat* of 510.6°, and but 669.4° latent heat, thus created by heat under 50 atmospheres of pressure, or about 750 pounds per square inch, and ending God only knows where.

Now we will consider what effect this principle must have exerted on the earlier surface formations of our globe, when this vapor of water was mixed with all the other gases that were simultaneously created by fire. First, it is thus shown that a sufficient amount of pressure and heat will increase the sensible heat of water, so as not only to render many things very much more soluble, but to actually melt, at least some, of the metals. That such states of transient pressure and heat existed at a certain period, cannot be denied by those who admit the theory of primitive heat formations, as all must have passed through these degrees from that of fusion to the present.

As water possesses so many other peculiarities, may it not have the additional intentional provision of becoming again liquid, or be reduced to hydrogen, under certain pressure and heat, thereby affording the nucleus of central fuel for the formation of worlds, and their elementary surface compounds, when and where required, as the pressure is removed, at the proper degree of temperature, and ignition or oxidation of this, thus formed, metallic hydrogen ensues.

It may be possible that the vapor again liquefies or solidifies after losing all its latent heat, under sufficient pressure; and on the release of pressure the elements of hydrogen and oxygen may become free, and re-unite when ignited as the vapor of water, whilst the excess of oxygen would form its union with bed rocks and supply that in the present atmosphere.

Since the date of first edition, wherein the above remarks were published, those astounding explosions of burning hydrogen from the sun, to some 200,000 miles above its surface, prove as thoroughly as can be possible, that solid hydrogen must exist in its interior, and thus supply the fuel for its formation. If this is so in the sun may it not be acting in a like manner, but with less power, in our globe, and thus create volcanic force, which by bursting occasionally under certain portions of the crust as described in the fourth chapter, produces earthquakes, and accounts for the formation and presence of water as discharged through red-hot craters.*

Now the total area of the oceans equals eight-elevenths of the surface of the earth, and as they have an average depth of three miles, it follows that the depth, if extended over the whole globe, would be more than two miles, or 10,560 feet. Taking the round number of 30 feet high of water as the representative of one atmosphere, and dividing the 10,560 feet thereby, we have 352 atmospheres of average pressure over the whole bed surface of the earth, which is more than seven times the pressure experimented on by the French Academy. Now if this amount of water was converted into vapor over the red hot earth, or was first formed as vapor (which seems the more plausible), it would, as a matter of course, being transferred from under to an overlying equal weight, exert the same pressure of 352 atmospheres, which the numerous other gases would increase to a still higher pressure, subject to some deductions for increasing length of circumference with greater altitude, etc., from divergence.

It appears, therefore, very certain that a much higher sensible temperature (which is governed by pressure on steam and water,) existed at some more remote period, than the 510° under 50 atmospheres, even surpassing the modulus of elasticity of steam;

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* The French chemist M. Pictet has just reduced hydrogen to both molten and solid conditions, under extremely high pressure, in practical experiments made at Paris in 1878, and realized my predictions of the first and second editions.

whilst the underlying saline solution in surface water, if any then existed, would exceed red heat.

These expressions are founded on the examination of pure water, but the degree is much increased when it contains other substances in solution. We will suppose that lime chloride may have largely composed one of the first saturated solutions from the released elements of fusion; as the escaping chlorine gas would exist, under more than 4 atmospheres of pressure, only as a liquid, that would form various chlorine compounds at more moderate temperatures.

This saturated solution alone, even at the present pressure of but one atmosphere, increases the boiling point from 212° to 264°, but all other freed gases and liquids which unite with water, as well as the first exudations of solid substances that were soluble therein, at the extremely high temperature then existing (which would embrace many that are now insoluble), would still further increase the boiling point; so that the trials of Dulong and Arago of pure water, which reached 510.6° under but 50 atmospheres, would in all probability have extended the degree of this then comparatively small and mixed solution to some 700° or 800° without further pressure. This appears but insignificant when compared to that which must have been then in action under the enormous influence of this vapor, increased still further by the following gases.

Oxygen, nitrogen, and hydrogen must have existed in enormous quantities, either uncombined as oxygen and nitrogen of the atmosphere, or in combination as the oxygen and hydrogen in steam, or in the more intensely heated and compressed unknown forms previously alluded to. Sulphurous acid, and carbonic oxide—changed to carbonic acid by combustion in air—must have been present, in gaseous conditions, as it is well known that they could not exist at any such temperatures, when combined as they are now.

Chlorine would for these same reasons have been present in immense quantity, either as a gas, or liquefied (at ordinary temperature) under a pressure of four atmospheres, but more probably as a gas,—for increased temperature would also require increased pressure for its liquefaction—this is, however, immaterial, as both carbonic acid and chloric gases, being heavier than the others, would form carbonated and chloridated steam to fall as water for further reactions, forming, at the suitably tepid periods, the various carbonates of lime, magnesia, etc., and the chloride of sodium, etc.; whilst the sulphurous acid would unite with the steam to fall in eroding showers, and produce solution with the other more suitable surface elements.

These are but a few of the gases which, with steam, composed this voluminous, mixed, heavy, and dark primeval atmosphere that surrounded the earth at this period. It affords interesting wonder as to whence all these gases proceeded. It is reasonable to suppose, that when a globe appears in luminosity and apparent combustion, that one or more of the inflammable gases must be present to support it; and strange as it may seem, the spectrum has recently demonstrated, by actual qualitative analysis, from the colors produced from mineral flames, that the sun, other fixed stars, and nebulous belts, are burning, or oxidizing, at this very moment, hydrogen, sodium, calcium, magnesium, iron, manganese, nickel, cobalt, chromium, titanium, etc., etc.

Whether the nebulous theory is approximately correct for solids, or not, some of the gaseous elements may have existed in very much more remote space than now; for just at the present state of rarefaction, we fail to even conceive the amazing amounts which have condensed from the gaseous, voluminous, and elastic, to the compact liquid and solid states; so that much of the intervening spaces may have been occupied by oxygen, nitrogen, or other more or less attenuated gases, collected by the attraction of the different spheres that traversed their respective orbits in space.

In connection with this theory of fire, it appears most strange as to what caused refrigeration; and, in addition to radiation, I see no better reason, than that the heat may have been transferred from the sensible to latent form, during the numerous chemical changes from gaseous to liquid and solid states. For instance, when hydrogen is burned, as it is commonly called, or oxidized, these gases combine to form water (its only apparent source), which contains, under one atmosphere's pressure, but 180° of sensible heat, and 1000° of latent heat; so that this considerable ratio having been thus stowed away from sensible forms, refrigeration was the consequence.

If this idea is correct, the various gases, by being composed into liquids and solids, would hasten the cooling, during this particular period of formation, to a very remarkable degree.

Notwithstanding this more speedy refrigeration, a very long hot period must have elapsed, as the first slates were being distributed and deposited, before the temperature would be sufficiently reduced for the formations of the inorganic crystalline carbonates of lime, magnesia, and the confused mixtures of slates, that preceded the more tranquil periods when water ceased to boil, under more natural and permanent atmospheric pressure.

It would be as absurd to suppose that changes were not then taking place, as that fish or animals of any kind could have existed during this hot epoch.

THE FORMATION OF THE EARLIEST CRYSTALLINE CLAY SLATES, FROM PRIMITIVE GRANITIC ELEMENTS.

In this state of wild confusion of gases and vapors, with general debris and dross, that encompassed the earth at this time, under the ever-varying actions of fire at the different parts of the surface, vast volumes of steam and accompanying vapors would be forced upwards from highly-heated oceans, seas, and lakes, which would create tremendously violent hurricanes of the compressed and heavy gases, that would sweep over the land with a distributive power far surpassing anything that can be conceived possible from the present ordinary causes for winds; thus scattering much spray from the hot oceans over the mountains, and drifting the comparatively light, thick debris,—that would even float in such an atmosphere,—over the slopes into the lower grounds, which, by long continued attrition, would completely crumble the more exposed and larger granitic rocks; whilst the moist steam and hot rains would carry away, in mechanical and chemical solutions, immense quantities of soda, lime, magnesia, etc., to these primeval ocean reservoirs, for subsequent reactions, precipitations and sedimentary depositions.

Large quantities of these substances must have been generally disseminated throughout, and dissolved from this surface scum, by highly heated water, that would by rendering the mass more cellular, hasten the disintegration and distribution of the quartz, feldspar and mica, which may have been, under these circumstances, transferred by such winds, to form the gneissose granites; and by further pulverization, or naturally smaller crystals, the earliest crystalline clay slates, as secondary formations, from primitive elements, on the irregular corrugations of the primitive bottom rocks, described in Chapter I.

I think the effects produced by floatation, in such a dense mixture of all the elements that fire could release, have been insufficiently credited; as an elastic medium of this enormous density must have held amazing quantities of the rock debris in mechanical suspension; and, therefore, as our—one atmosphere's density—floats a feather and impalpable dust, it cannot be doubted that such as must have then existed, when assisted by ponderous winds, would have floated the sands, or even the loose rocks themselves, into the more tranquil slopes and valleys. It also seems possible that many free elements may have been thus suspended to combine, by chemical crystallizations, into heavier solid forms, to fall in continual showers, and aggregate, in course of time, into the Azoic bed-rock. This would fully account for gneiss and other formations, which are now but conjectural problems.

As silicic acid forms the half of all rocks, and enters, *as an acid*, into their constitutions to form silicates, may it not be possible and even probable, that it might have acted as the receiving solution, whilst water was created as its diluting associate, under extreme pressure and temperature, exceeding that of its modulus of elasticity, and after the pressure became sufficiently reduced, the silicious solution was evaporated, by the very creation of the vapor of water (an inverse means), and this peculiar crystallization was the residual result?

In connection with these distributions and depositions of the crystalline azoic formations, most of which, I think, were deposited before water ceased to boil, two very important facts must not be forgotten, that the first so-called upheavals of all the primitive mountains, compared with the subsidence of the ocean-beds, were by no means so different as they are now in their elevations and depressions, or were the oceans anything like as extensive as they have since, by condensation of steam, become; so that, for these reasons, the very hot ocean waters may at the earliest periods have had the separating barriers of the old and new world's continents, just as they have at present, with but the difference in the depths of the water as compared to later periods, and by partaking of only the slight tidal motion that is now produced by the action of the moon, the distributions and sediments would be settled in situations that conformed to such conditions; but, as the earth continued to refrigerate, the vapor of water would condense, and increase the oceans so much that the waters would submerge all the lower lands of the present continents of the world, leaving nothing above it but a few peaks and comparatively short ranges of the tops of the mountains as mere islands. The ocean, having risen from its minimum depth and surmounted its barriers, followed the moon's accelerative attraction, and wrought at the greatest height of its waters uncontrolled sway on the general surface debris, and thus deposited its various azoic (non-fossiliferous) rocks at all levels during its ebb from the land; so that the mountain regions of dry land continued to increase as the ocean-beds sunk and withdrew the waters therefrom.

It may be here repeated, that a subsidence of the ocean's vast comparative areas, of but 100 yards, would have laid bare all the low lands of the world. This liquid reservoir and distributor of mud, aided by contraction and its consequences, acting in conjunction with chemical solvents, the mechanical disintegrators of heavy winds, and the enormously plentiful deluges of rain, during this period of steam, shaped the transverse hills and valleys of the primitive rocks, and with their debris reformed what the miner must understand as the *first secondary rocks*, from primitive rock-debris, being the latter stage of this peculiar azoic formation. These rocks are all of crystalline appearance, and apart from the fineness of the grain, and the presence of talc, extra mica, hornblende, etc., do not differ very much from the composition of the granites, from which they are derived. Crystallization, with the absence of too perfect cleavage and fossiliferous remains, are imperative characteristics of this age of formation.

There is also, the compact variety of crystalline carbonate of lime, granular limestone, which was probably deposited at or towards the termination of the period, from the chemical solution of chloride of lime, as the temperature of the boiling solution became sufficiently reduced for the carbonic acid from the atmosphere, or the hot water, to unite therewith and precipitate carbonate of lime, the chlorine being released to form chlorine water for other combinations, as that of chloride of sodium, etc.

These limestones, being formed during the hot period, consequently lack fossils and cleavage, and frequently form irregular combinations with the other mechanical ingredients from neighboring rocks. These must not be confounded with the modern coralline and stratified mud formations, in which well-formed, perfect fossils abound. For the miner's purpose, the rocks and deposits, described in these chapters, will embrace all the massive granular kinds, as the various granitic rocks, crystalline slates, and limes, as well as the hard greenstones, and some of the porphyries that are known to be of settled formation, and not produced by the more modern and local volcanic action.

As these elements were first obtained by fusion, during the evulsion of mineral matter, they were more or less impregnated therewith at the time, and what happened to be volatilized, and escaped into the atmosphere, were sooner or later collected and reconveyed to the general solution, that at the proper time, deposited the base mineral oxides and chlorides upon this first and only bottom receptacle for progressive formation, and which formed the general stock of the salifiable bases that were slowly transferred to the veins of future ages, and precipitated by the many re-agents that happened to be present during long periods of time.

The metals which have been profitably extracted from the true fissure veins of these formations, are chiefly iron, copper, tin, lead, zinc, and silver in combination with copper or lead; but, less frequently, the ores of silver, in such settled positions.

When intrusive and comparatively recent volcanic action *approaches* these primitive and secondary formations, silver is more frequently found in its constitutional forms, and in greater abundance, than when it is *very far* from such action.

Gold has been found in profitable quantities in such primitive, or primo-secondaries, when volcanic action has uplifted, distorted and tilted the latter strata to a considerable angle; sometimes it is then found in the primitive, very near the junction, but more frequently in the talcose clay slates. Silver appears to have been of more recent formation, and, as but little of it will also suffice for profits, it has been consequently worked from more numerous strata than many of the more plentiful base minerals. I have often thought, that during the period of the general volatilization of all the minerals and metals, there may have arisen just as much silver and gold as many other metals; but, when the surface reactions commenced, silver, if not a chloride, would unite with some *soluble chloride*, as chloride of sodium, to a very *insoluble* chloride of silver, that would be dispersed with the bed-rock formations, but, being insoluble with acids, would never be transferred to, and collected in, veins or pockets for profitable extraction, as is the case with the many soluble base minerals. Gold would also, from being soluble in chlorine or chlorine water, be mostly dispersed throughout the ocean, or precipitated in after times into infinitesimally small metallic particles, that would be also forever insoluble in any other natural solvent, after the chlorine had united to other elements, for which it possessed a stronger affinity, than for gold.

The shell of the earth still continued to crush laterally, to create room for its settlement, on the molten faster-contracting interior, during these formations, as it did in the primitive period; and in both cases, as would be supposed, not in a very universally regular manner; so that the primitive secondary Azoic deposits do but seldom conform to or cover the primitive bottom, in any very equal layers over the mountainous districts of greatest disturbance, wherein the miner requires information. These Azoic formations would continue to dry and bake into concreted rock, by the underlying heat, beneath the pressure of the after-deposition of the Paleozoic, Mesozoic, and Cenozoic rocks; and the distorting influences would also be occasionally acting, in a more moderate scale, to its further displacement, as may be seen in the formations of all ages.

At about this and subsequent periods, it frequently happened that the overlying azoic rocks *slid upon* the primitive bottom of granite, when the latter was being crushed and thickened into mountains; and in a manner sometimes toothed into, or doubled back, against such elevations; or in other words, continued with the horizontal motion of the general adjoining rock until it arrived at about where the partial thickening of the granite occurred, when such extraordinary distortions and strange foldings resulted—by its sliding over the primitive rock bottom—as to render the old theories for the *direct upheaval* of mountains quite inadequate for the effects produced; for nothing but *directly lateral separate shifts* could have caused the very irregular features of the crushed or crumbled broken granite, and the various jumblings of forms of the secondary strata, which are occasionally seen by the practical miner.

CHAPTER III.

THE ROCK FORMATIONS OF THE PALEOZOIC, MESOZOIC AND CENOZOIC TIMES—WHERE FOSSILIFEROUS REMAINS OF BIRDS, FISHES, AND ANIMALS ARE FOUND.

> "And the spirit of God moved upon the face of the waters,"
> "And God said, let there be light, and there was light."
> *Genesis*, chap. I, verses 2 and 3.

The preparatory stages of rock formations described in Chapters I and II, may have required billions of years to accomplish, and as plainly shown by the quotations from Genesis, this long dark entire time, preceded the first day's (or period's) light, and week's work of organic creation.

These life sustaining times, now to be described, have been subdivided by geologists into ages, and the ages into eras, and periods of formation.

The Paleozoic Time is the principal one of these which concerns the miner; the others should be studied but for recognition, and avoidance. This commenced an era of more tranquil and natural formations, when water had ceased to boil, under an atmosphere that approached more closely to the present; when the lower order of living creatures could exist, and leave their records embedded in a soft stratified mud, to seal and solidify for the future inspection of the Almighty's master creation, Man. This mud solution was mostly such as was not chemically precipitated, or too impalpable for settling during the period of ebullition, and which contained, in solution, those elements that were still partially or wholly soluble in tepid water; some of which would be precipitated on cooling, whilst the remainder supplied the organisms with lime, etc., for the formations of the modern coralline fabrications and stratified rocks, that now overlie those of the Azoic crystalline deposits, which more immediately concern the miner of metallic minerals.

> "And God made the firmament, and divided the waters which *were* under the firmament from the waters which *were* above the firmament."
>
> *Genesis*, chap. I, verse 7.
>
> "And God said let the earth bring forth grass, the herb yielding seed, *and* the fruit tree yielding fruit after its kind, whose seed is in itself upon the earth."
>
> *Genesis*, chap. I, verse 11.
>
> "And God said let the waters bring forth abundantly the moving creature that hath life, and fowl *that* may fly above the earth in the open firmament of heaven."*
>
> *Genesis*, chap. I, verse 20.

This Paleozoic Time (of stratified rocks, and these organic creations) embraces the Silurian Age of Mollusks, the Devonian Age of Fishes, and the Carboniferous Age of the Coal-field deposits. The Silurian Age is again divided into the Lower Silurian and Upper Silurian Eras, the first embraces the Potsdam, Trenton, and Hudson Periods; the first, or Potsdam, being composed of Potsdam sandstone and calciferous sand-rock; the Trenton, or second, of Chazy limestone, and Trenton, Black River and Bird's-eye limestones; the Hudson, or Third Period, of Utica shale and Hudson River Group; whilst the Upper Silurian Era embraces the Niagara, Salina, and Lower Helderberg Periods, the Niagara Period being composed of Oneida conglomerate, Medina sandstone, with the Clinton and Niagara Groups; the Salina Period principally of saliferous beds; and the Lower Helderberg Period of the Lower Helderberg Group of Aymestry limestone. The Devonian Age of Fishes, embracing the Old Red Sandstone, is divided into the Oriskany, Corniferous, Hamilton, Chemung and Catskill Periods; the Oriskany Period being composed of Oriskany sandstone; the Corniferous Period of Cauda-Galli grit, Schoharie grit, and Upper Helderberg limestones; the Hamilton Period of Marcellus shale, Hamilton Group, and Genesee slate; the Chemung Period of the Portage and Chemung Groups; and the Catskill Period of Catskill red sandstones.

The Lower and Upper Silurian formations, when near to or adjoining the Azoic, primitive, or secondary rocks, and when comparatively free from well-defined fossils, other suitable conditions being present, frequently have veins that contain profitable quantities of lead, antimony, zinc, and iron; and when slightly invaded and metamorphosed, or tilted by more recent volcanic action, pockets of silver are often found in both carbonate of lime and the combined carbonates of lime and magnesia, as well as in the clay slates.

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*It is very remarkable that only fishes and fowls were first made,—which strictly conforms with Genesis and with the instable condition of the dry land,—for as man and animals could not exist and multiply on ground that must have been, at this time, too frequently submerged, they were necessarily the last of creation.

When talcose, chloritic, and ordinary clay slates have been thus tilted for a considerable distance, and uplifted as a margin to an ancient ocean, gold has been found in greatest profusion throughout the world, in reefs that accompany the divisions of the stratum, rather than in true fissure veins; but those which deviate from the general line of cleavage of the stratum, and take their *own fractured route* at times and places, have been much more profitable than others that always conform thereto.

The Carboniferous Age terminates the Paleozoic Time, and is divided into the Sub-carboniferous, Carboniferous and Permian Periods; first, the Sub-carboniferous, of sub-carboniferous or mountain limestone and millstone grit; the Carboniferous, of the various series of strata of the coal measures; and the Permian Period of the Permian Groups of red sandstone and marls, with magnesian limestone.

The formation of these Carboniferous Ages should be closely studied by the coal-miner, and the recorded facts laid down in numerous geological treatises, regarding the ages of the fossil shells, must frequently be referred to, that he may know when he is, or is not, on ground that contains or covers coal-beds, as well as the particular position for the different periods of the deposits on the same field, so that errors may be prevented.

It would require much space to fully illustrate this subject, which, to be beneficial, should be exhaustive. I have, however, made the following extracts from Dana's *Manual of Geology, and the authors he has quoted,* to expose the general geological characteristics, and immense extent of the American coal-fields, already discovered.

For further information on this most interesting and important subject, you should consult other books written for practical coal-miners, as no natural products are more imminently valuable for a nation's continued prosperity than great abundance of coal and iron.

"EPOCH OF THE COAL MEASURES.

I. DISTRIBUTION OF THE COAL AREAS.

"1. The great *Appalachian* coal field, covering parts of Pennsylvania, Ohio, Virginia eastern Kentucky, eastern Tennessee, and Alabama. The workable area is estimated at 60,000 square miles. The whole thickness of the formation is 2500 or 3000 feet; aggregate thickness of the included coal-beds, over 120 feet in the Pottsville and Tamaqua Valley, about 62 feet near Wilkesbarre, 25½ feet at Pittsburg. The area is partly broken up into patches in Pennsylvania, in the centre of the State, between Pottsville and Wyoming, are the famous anthracite beds, divided into many distinct patches; and in the western part commences the great bituminous coal-field which spreads into Ohio and stretches on south to Alabama.

"2. The *Illinois and Missouri*, covering a very considerable part of Illinois, part of Indiana and Kentucky, and, west of the Mississippi, portions of Iowa, Missouri, Kansas, and Arkansas. Estimated area, 60,000 square miles. Whole thickness of the formation, in Missouri, 600 to 1000 feet; in western Kentucky, nearly 3300 with about 70 feet for the aggregate thickness of the coal-beds.

"3. *Michigan*, situated about the centre of the peninsula. Estimated area, about 5000 square miles. Whole thickness of the formation, 123 feet; rests upon a sandstone, probably of the Millstone grit epoch, which is 105 feet thick.

"4. The *Texas*, covering several of the northern and northwestern counties.

"5. The *Rhode Island*, lying between Providence and Worcester in Massachusetts, and opened at Cumberland, north of Providence, at Portsmouth, 23 miles south, and also showing thin seams at Newport and elsewhere; in Massachusetts, outcropping at Mansfield, 15 miles northeast of Providence, at Wrentham, 5 miles from Mansfield, and at Worcester. Estimated area, 1000 square miles.

"6. The *New Brunswick and Nova Scotia*, covering part of New Brunswick, Nova Scotia, Prince Edward's Island, and Newfoundland. Estimated area, 18,000 square miles. Whole thickness of the formation of the Joggins, including the beds of the Millstone grit epoch, 14,570 feet, the number of included coal-beds is 76, some of them being very thin, and the aggregate thickness 45 feet. (Logan.) These coal-beds are situated in a part of the Coal measures, 2819 feet thick, near the middle of the series. At Pictou there are six beds of coal, with an aggregate thickness of 80 feet. (Dawson.)

"The total number of square miles of all the productive coal-fields of the United States is 125,000.

"Besides the above, there is the *Arctic* Coal region, which has been observed on Melville and Bathurst Islands, Banks Land, etc., and the *Rocky Mountains*, both of which are unexplored.

"Limestones of the Carboniferous period—formerly supposed to be Subcarboniferous have a wide distribution over the summit and both the eastern and western slopes of the mountains. This limestone has been observed at the Black Hills in Dakota, and the Laramie Range; about the head-waters of the Missouri; at the South Pass of the Rocky Mountains; in the ranges south of Pike's Peak, and east and west of Santa Fé, New Mexico; in the great basin of the Colorado; and it probably underlies to a considerable extent the Mesozoic rocks of the Rocky Mountain slopes west of the Mississippi.

II. ROCKS.

"1. *Kinds of rocks, and stratifications.*—The coal measures include stratified rocks of all kinds—sandstones, conglomerates, shales, shaly sandstones, limestones; and the limestones are generally impure, or magnesian. There is the same wide diversity that occurs in the Devonian, with more numerous and rapid transitions than were common in that age. Moreover, the rocks differ much in different regions.

"The Coal beds are additional layers in the series, interstratified with the shales, sandstones, conglomerates, and limestones. But they are thin, compared with the accumulation of rock-strata. The Coal measures contain, generally, 50 feet or more of beds of rock to *one foot* of coal.

"Iron-ore beds also occur, making other thin layers in the series, and rendering the Coal regions the best iron regions of the globe.

The following section is an example of the alternations (beginning below):

1.	Sandstone and conglomerate beds	120	feet.
2.	COAL	6	"
3.	Fine-grained shaly sandstone	50	"
4.	*Siliceous iron-ore*	1½	"
5.	Argillaceous sandstone	75	"
6.	COAL, upper 5 feet shale, with fossil plants, and below a thin clayey layer	7	"
7.	Sandstone	80	"
8.	*Iron-ore*	1	"
9.	Argillaceous shale	80	"
10.	LIMESTONE (oolitic), containing *Producti*, *Crinoids*, etc	11	"
11.	*Iron-ore*, with many fossil shells	3	"
12.	Coarse sandstone, containing trunks of trees	25	"
13.	COAL, lying on 1 foot slaty shale, with fossil plants	5	"
14.	Coarse sandstone	12	"

"The alternations are thus various, and may follow any order. The shales, sandstones, conglomerates and limestones resemble the corresponding rocks of other periods, and *they are distinguished as belonging to the Coal measures only by the fossil plants or animal relics they may contain.* Disastrous errors are often made when this rule is not regarded.

"The beds, even when thick, whether of coal or any of the rocks mentioned, have, in some districts, a limited lateral extent; yet, in this respect the Coal measures differ little from earlier formations. Some of the larger beds of coal are supposed to spread continuously over many thousand square miles of area.

"In connection with the Coal measures of Rhode Island there are extensive beds of quartzose conglomerate, which outcrop at Newport and elsewhere, and form a bold feature in the landscape at "Purgatory," 2½ miles east of Newport. They occur, also, in Massachusetts, between this region and Boston, showing well about Roxbury. The exact position of the beds in the series is not known, as the rocks have undergone great disturbance, and in some places so much metamorphism that the cementing material is a talcose schist. At Taunton, Massachusetts, its pebbles have occasionally been found to contain Lingulæ of the Potsdam sandstone (*Lingula prima*), proving that they are pebbles of this Primordia rock; but whence derived is unknown.

"Besides the rocks mentioned, a buhrstone occurs in beds several feet thick, in Ohio. It is a cellular, flinty, siliceous rock, valued highly for millstones.

"The limestones are more extensive in the Coal measures of the Mississippi basin than in those of Pennsylvania and Virginia; while, on the contrary, conglomerates are much less common in the West. This accords with the fact, learned from the earlier ages, that the Appalachian region is noted for its conglomerates and sandstones, and the interior basin for limestones.

"In Wayne county, in Western Pennsylvania, there are 80 feet of limestone in 250 feet of Coal measures; and near Wheeling, on the Ohio, twice this thickness of limestone. In Missouri, there are 150 feet or more of the former to 650 of the latter. In the lower 150 feet of the Missouri section, there are, however, but 8 feet of the limestone, and in 900 feet of the Lower Carboniferous, in Western Kentucky, only 10 feet. The limestones included among the strata appear often to have a limited lateral range, instead of the uniformity over extended areas common in earlier periods.

"The rock underlying a coal-bed may be of either of the kinds mentioned; but, usually, it is a clayey layer (or bed of finer clay), which is called the *under-clay*. This under-clay generally contains fossil plants, and especially the roots of Carboniferous called *Stigmariæ*, and it is regarded (as first shown by Logan) as the old dirt-bed in.

which the plants grew that commenced to form the coal-bed. In some cases, trunks of trees rise from it, penetrating the coal-layer and rock above it.

"The Nova Scotia Coal region abounds in erect trunks, standing on their old dirt-beds. Each of the 76 coal seams at the Joggins has its darker clayey layer, or dirt-bed, beneath. In 15 of them, there is only a trace of coal; but these, as well as the rest, contain remains of roots (*Stigmariæ*), and often support still the old stumps. (Dawson).

"The rock capping a coal-bed may be of any kind, for the rocks are the result of whatever circumstances succeeded; but it is common to find great numbers of fossil plants and fragments of trees in the first stratum.

"The shaly beds often contain the ancient ferns spread out between the layers with all the perfection they would have in an herbarium, and so abundantly that, however thin the shale be split, it opens to view new impressions of plants. In the sandstone layers, broken trunks of trees sometimes lie scattered through the beds. Some of the logs in the Ohio Coal measures, described by Dr. Hildreth, are 50 or 60 feet long and 3 feet in diameter.

"The thickness of the coal-beds at times hardly exceeds that of paper, and again is from 30 to 40 feet. The beds also vary in purity, from coal with but 1 per cent. of earthy matter, to dark-colored shales, with only a trace of coal. The thickness is seldom over 8 feet, and the impurities ordinarily constitute from 7 to 15 per cent.

"The Pittsburg seam, at Pittsburg, Pennsylvania, is 8 feet thick. It borders the Monongahela for a long distance, the black horizontal band being a conspicuous object in the high shores. It may be traced, according to Rogers, into Virginia and Ohio, over an erea at least 225 miles by 100; and even into Kentucky, according to Lesquereux. But it varies in thickness, being 12 to 14 feet in the Cumberland basin, 6 feet at Wheeling, 5 at Athens, Ohio, and on the Great Kanawha; farther south, at the Guyandotte, 2 to 3 feet.

"The 'Mammoth Vein,' as it is called, which is exposed to view at Wilkesbarre, Pennsylvania, is 29½ feet thick. It is nearly pure throughout, although there are some black shaly layers 1 to 12 inches thick. The same great bed is worked at Carbondale, Beaver Meadows, Mauch Chunk, Tamaqua, Minersville, Shamokin, etc.

At Pictou, in Nova Scotia, one of the coal-beds has the extraordinary thickness of 37½ feet and a second 22½ feet.

"2. *Structure of the Coal.*—A bed of coal, even when purest, consists of distinct layers. The layers are not usually separable, unless the coal is quite impure from the presence of clay; but they are still distinct in alternating shades of black, and may be seen in almost any hand specimen of the hardest anthracite, forming a delicate, though faint, banding of the coal.

"In much of the bituminous coal of the Mississippi basin, a cross-fracture shows it to be made up of alternate laminæ of black, shining, compact bituminous coal, and a soft, pulverulent carbonaceous matter, much like common charcoal.

"The coal itself varies much in character. In some regions, as in the Schuylkill (at Pottsville, Mauch Chunk, etc.) and Wilkesbarre coal-fields, at Peak Mountain, in Virginia, and in Rhode Island, it is of a kind called *Anthracite*, which is non-bituminous, and burns with very little bluish flame. At Pittsburgh, and through nearly all the Appalachian coal-field, and in the other coal areas of North America, it is *Bituminous* coal, which burns readily with a bright-yellow flame.

"The bituminous coal is either of the ordinary brittle kind, breaking into lustrous angular pieces, or the compact *Cannel coal*, distinguished by its firmness, slight lustre, conchoidal fracture, and the absence of any laminated structure. Cannel coal often graduates into ordinary bituminous coal.

"In many places, there are vegetable remains in the coal itself, such as impressions of the stems of trees, or leaves, or charcoal-like fragments, which, in texture, resembles charcoal from modern wood.

"Even the solid anthracite has been made to divulge its vegetable tissues. On examining a piece partly burnt, Professor Bailey found that it was made up of carbonized vegetable fibres.

"*Pyrites* (sulphuret of Iron) is sometimes disseminated through the coal-beds in nodules or seams, to the serious injury of the coal. Such coal crumbles down on exposure to the air, and gives forth sulphur fumes when burnt. Even the best of mineral coal contains traces of pyrites; and to this is owing the sulphur smell ordinarily perceived from coal fires.

"3. *Iron-ores.*—The iron-ore beds are usually from a few inches to 3 or 4 feet in thickness. They contain the ore in concretionary masses or plates of a stony aspect. The most common but not most valuable kind has a grayish-blue and drab color on a fresh surface of fracture, and differs from limestone in being unusually heavy: this ore, called *clay ironstone*, is an impure spathic iron or *chalybite*. Another variety of *ironstone* is an impure *hematite*, affording a red powder. Still another kind is an impure *limonite*, having a reddish-brown or yellowish-brown color, and affording a brownish yellow powder: beds of this variety are few, but widely extended, thick and valuable.

"4. *Upper and Lower Coal Measures.*—The Coal measures are sometimes divided into the Upper and Lower Coal measures. The most convenient division is above the 'Mammoth bed' of Pennsylvania, as there is a marked change in the flora from this point. It has been proposed to make the Mahoning sandstone the dividing bed, above the Upper Freeport coal-bed, which is the third above the so-called Mammoth bed in the Pennsylvania series. Another great sandstone stratum, called the Anvil Rock, occurs in Kentucky, above the twelfth coal-bed in the Kentucky series; and this has also been made a dividing stratum in the measures. There is nothing in the fossils that renders the subdivision at these places of geological importance. (Lesquereux.)

"The great Anthracite region of Pennsylvania is largely Lower Carboniferous. The Upper Carboniferous is present there (at Pottsville, Shamokin and Wilkesbarre) up to the top of the Pittsburg group (Lesley); but the rest does not extend so far eastward. The greatest development of the lower coal was in Pennsylvania; and of the upper, in the States farther west. The highest beds in the series appear to occur west of the Mississippi, in Kansas, where they merge into the Permian. There are, however, according to McKinley, 3,000 feet of barren Coal measures above the level of the Pittsburg coal, in the southwest corner of Pennsylvania and the adjoining part of Virginia, and it is not certain how far upward they may reach in the series.

"5. *Equivalency of the Appalachian and Illinois Coal Measures.*—There is great difficulty in arriving at safe conclusions as to the equivalency of the beds in the different coal basins, because the beds of rock as well as of coal—even those that are the thickest—vary much at comparatively short distances over the country. Moreover, as the basins are wholly disconnected, there is no chance to trace even a single stratum from one to another. It is often assumed that the Appalachian and Illinois beds were once united, and were afterwards divided by the uplift of the Silurian about Cincinnati, and extensive denudation accompanying it. But it has been shown that this uplift probably antedates long the Carboniferous Age; and, if this were so, the connection in those latitudes is impossible. It is evident, therefore, that only the most general conclusion on the subject of equivalency can be accepted as established facts. The principal investigations on this subject are those of Lesquereux, who has brought to it a thorough knowledge of the coal plants.

"The Coal measures of Pennsylvania and the States west include twelve to eighteen distinct workable coal-beds, besides thinner seams, the number varying in different regions from certain beds being comparatively local. In this series there are two beds that have special prominence on account of their thickness and the wide range they are believed to have.

"There are, *first* the *Mammoth Anthracite vein* of Pennsylvania, which is the second or third from the bottom, not far from the Millstone grit.

"*Second*, the *Great Pittsburg bed*, the seventh or eighth above the Mammoth vein.

"The following are the equivalents of the beds, according to Lesquereux:

"(1.) *Mammoth bed* (Second workable Pennsylvania bed).—The bed at Leonards, above Kittaning, Pennsylvania (3½ feet thick), etc.; Mahoning Valley, Cuyahoga Falls, Chippewa, etc., Ohio; the Kanawha Salines; the Breckinridge Cannel Coal and other mines in Kentucky, the first (or second) Kentucky bed; the lower coal on the Wabash, Indiana; Morriss, [illegible]; Illinois.

"(2.) *Pittsburg bed* (Eighth Pennsylvania bed).—Bed at Wheeling; the *Well* coal, at Mulford's in Western Kentucky, the eleventh Kentucky bed.

"The *Gate and Salem beds* correspond to the *Upper Freeport* (or fifth bed Western Pennsylvania; *Pomeroy* coal, Ohio, situated below the Mahoning sandstone; the *Curlew* coal, of Curlew Hill, Kentucky, or the fourth Kentucky bed.

"In Kentucky, fifteen or twenty distinct coal-beds exist. The eleventh is supposed to correspond to the Pittsburg bed, and the others are above it. Above the twelfth, there is the massive sandstone, 40 to 50 feet thick, called the *Anvil Rock*, from the form of two masses of it in Southwestern Kentucky. Six or seven coal-beds occur above the Anvil Rock, in about 500 feet of rock; but they are very thin; the whole amount of coal in this thickness is about five feet. (D. D. Owen.) The thickness of rock in the Coal measures below the top of the Anvil Rock is about 1,000 feet, and of the included coal-beds about 40 feet; making, in all, for the western Coal measures of Kentucky, a thickness of 1,500 feet, in which are 45 feet of coal.

"6. *Sections of the Coal Measures.*—In Western Pennsylvania, the western Coal measures, to the top of the Upper Freeport Coal, inclusive, consist, according to Lesley, of the following beds. (Manual of Coal and Topography, by J. P. Lesley, 12mo. 1856. Philadelphia: Lippincott & Co.) The numbering of Lesley by the letters of the alphabet is added; and also that by Lesquereux (the latter in parentheses), as made out from a supposed parallelism between the Kentucky and Pennsylvania beds:

		FEET.
	Millstone Grit	?
1.	COAL No. A, with 4 feet of shale [1 A]	6
2.	Shale and mud-rock	40
3.	COAL No. B [1 B]. (Equivalent of Mammoth bed)	3–5
4.	Shale, with some sandstone and iron-ore	20–40
5.	FOSSILIFEROUS LIMESTONE	10–20
6.	Buhrstone and iron-ore	1–1½
7.	Shale	25
8.	COAL No. C. The Kittaning Cannel (equivalent of the Cannel of Peytona, Virginia, and Darlington, Pennsylvania). [2]	3½
9.	Shale—soft, containing two beds of coal 1 to 2½ feet thick	75–100
10.	Sandstone	70
11.	Lower Freeport COAL bed No. D [3]	2–4
12.	Slaty sandstone and shale	50
13.	Limestone	6–8
14.	Upper Freeport COAL, No. E of Lesley [4]	6
15.	Shales	50

"The *Upper Coal measures* are continued in Western Pennsylvania, to the Pittsburg coal inclusive, as follows:

		FEET.
1.	MAHONING SANDSTONE	75
2.	COAL No. F [5]	1
3.	Shale; thickness considerable	?
4.	Shaly sandstone	30
5.	Red and blue calcareous marls	20?
6.	COAL No. G [6]	1
7.	Limestone, fossiliferous	2
8.	Slates and shales	100
9.	Gray, clayey sandstone	7
10.	Red marl	10
11.	Shale and slaty sandstone	10
12.	Limestone, non-fossiliferous	3
13.	Shales	32
14.	Limestone	2

		FEET.
15.	Red and yellow shale	12
16.	Limestone	4
17.	Shale and sand	30
18.	Iron-ore (spathic)	25
19.	Limestone	1–1½
20.	Pittsburg COAL, No. H of Lesley [11]	8–9

"The upper part of the *Upper Coal measures* (above the Pittsburg bed) in Western Pennsylvania (Waynesburg, Greene County), according to Lesley, includes, commencing below

		FEET.
1.	Shale, brown, ferruginous and sandy	30
2.	Sandstone, gray and slaty	25
3.	Shale, yellow and brown	20
4.	Limestone—the Great Limestone south of Pittsburgh (including two COAL beds 2½ feet and 1 foot	70
5.	Shale and sandstone	17
6.	Limestone	1
7.	Shale and sandstone	40
8.	COAL	6
9.	Shale, brown and yellow	10
10.	Sandstone, coarse, brown	35
11.	Shale	7
12.	COAL	1½
13.	Limestone 4 feet, shale 4, limestone 4, shale 3	15
14.	Shale 10 feet, sandstone 20, shale 10	40
15.	COAL	1
16.	Sandstone (at Waynesburg), with 4 feet of shale	24

"Sections of the strata of Kentucky, Missouri, Ohio and Michigan will be found in the Geological Reports on those States, and others of Nova Scotia, in Dawson's Acadian Geology, and the Quarterly Journal of the Geological Society, 1854, page 60. Mr. Lesquereux has published a memoir on the equivalency of the coal-beds of the United States in the Geological Report of Kentucky.

"The relations of the sandstones, limestones and shales that alternate with the coal-beds over the wide region stretching from the Appalachians west, are but partially understood. Although these strata seem to be generally limited in range, there is still an equivalency to be ascertained for the whole succession. The rocks, as in other ages, are consecutive records of the events of the period; and, until fully elucidated, the history of the American Carboniferous era will remain imperfectly known."

Above this Paleozoic Time, and these Carboniferous Ages, the Mesozoic Time, or Reptilian Age, follows, embracing the Triassic, Jurassic and Cretaceous Periods, which are respectively composed of the Trias, Lias, Oolite and Wealden; and the Greensand, Lower Chalk and Upper Chalk, with Flint formations: and, lastly, the Cenozoic Time, or Mammalian Age, with its Tertiary and Post-Tertiary Periods of Eocene, Miocene and Pliocene. The Post-Tertiary formations, as before stated, should be avoided by metallic miners.

It will be interesting to notice the succession of deposits above the first Azoic secondary primitives' hardened surface, which will be much facilitated by referring to Webster's Pictorial Dictionary of 1870, where these strata are illustrated and explained under the word "Geology," page 566. The first formation is that of the peculiar rocks of the Potsdam sandstone, the first Calciferous sand-rock; then the Chazy, Flag and Bird's-eye limestones, not the Utica shale and Hudson River Group. These were probably formed during the cooling from the warm to the tepid water periods, by almost entirely chemical precipitation of carbonate of lime, in comparatively quiet and small, but, from condensation, rapidly increasing oceans and seas. Thus—favoring a theory which has been fully described—the ocean water, when overflowing all the lower lands of the world, was urged with *acceleration* forward by the *moon's attraction*, thereby rounding and sweeping the larger Oneida conglomerate rocks into the hollows and flats. The ocean beds, by straightening, or sinking, must have caused the withdrawal of the water from the land after this period; so that the *continental barriers* controlled the action of the moon, and re-obtained a mere tidal oscillation and a more tranquil state of the waters. Again, sandstone (the Medina) appears, as a recurring precursor to a new series, and recorder of a change of water-level, in which the succeeding Clinton and Niagara groups, Saliferous beds, and Helderberg groups, were deposited.

This is to be noticed for *first evidence of salt* in the Saliferous beds, which may have been supplied from the formation of chloride of sodium of the oceans, *after the chloride of lime* had been precipitated, or as the water released salt *from a colder solution*, which it had not previously done during the Azoic Time. Again, another changing of the water-level is recorded by the Oriskany sandstone and the Cauda-Galli and Schoharie grits, which received the deposits of the Upper Helderberg limestones, Marcellus shale, Hamilton group, Genesee slate, and the Portage and Chemung groups. Again, the Catskill red sandstone covered the Devonian Age of fishes, and underlay the Sub-carboniferous mountain limestones, which are of great depth, and occupied a whole period for formation. Again is evidenced, by the general Millstone grit formation that preceded the coal deposits, a more extensive action of water than any since that of the Oneida conglomerate. On this Millstone grit the thin layers of the underlying strata of the different, similarly produced, successive coal measures have been deposited. Some authors have stated that the vast quantities of gravel, mud, and sand, which have been washed down from the mountains into the plains and ocean beds, have caused these depressions; but they fail to say anything about their displacing an equal bulk of water, which must elevate its surface and consequently cause an almost corresponding overflow of the land.

These more recent throes, or shifts of the earth's surface, have been so varied, in innumerable localities, that a thousand geologists would fail, during the collective labors of their lives, to fully expose the subject. We may, however, easily perceive that a slight depression of the more extensive ocean beds would cause the waters to recede from the much smaller areas of the lowlands, and that a drop of but a few feet of the mountains would again submerge coal-fields, for a repetition of the process. That such has taken place, repeatedly, is as certain as that at this time it is slowly changing the level of hundreds of miles of the South American continent. It is probable that these irregular drops of certain portions of the surface were caused by the varying sequence of subsidence of the crust upon different points of support previously alluded to, as now here, and then there; so that when another and greater area of the outer shell overlies a larger internal hollow than it will bear, it naturally crushes sideways and sinks to rest upon this particular spot of the inner globe. In the early times, the crust had not solidified, but to a comparatively slight depth, and consequently, the settlings, or deviations of surface contour, to follow the contracting interior, were more easily accomplished than is the case now, with the deeply solidified and more thoroughly settled shell.*

It may be doubted if extensive mountains, apart from volcanic action, have at any time really arisen, or increased distance from centre, seeing that their height, as compared with the radius of the earth, is but from two to five miles in 4,000, or less than one part in a thousand; the whole surface has settled much more than this, and the ocean beds, by sinking faster than the mountains, the latter, by lagging, only appear to be elevated.

In view of these unmistakable facts—of the several growths and burials of the coal seams, with their similar anterior and posterior strata—it is far more natural to suppose that this *difference of contractional travel, or settling of the surface,* had caused these changes, than the real uplifting of such extensive regions; indeed it appears strange that so little difference existed on a contracting globe of such diameter, as the smallest metal globe shows, on solidification from molten to solid state, a very much greater disparity. The American continent, by lying so directly across the attraction of the moon, must have played a very important part in these formations, as a trifling difference of downward travel of this land, and the adjoining ocean beds, would have flooded the whole of the lowlands of America, as Central America became the flood-gate or barrier of the world's waters. If the lowlands of Europe, Asia and Africa were submerged at the same time, the ocean would follow in uncontrolled, accelerating, circumnavigating sway, in one direction after the moon; and even glaciers would vary their voyages accordingly, over such strangely abraded routes as are now exposed.

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*The reader should fully understand and remember this principle of settlement, as I attach great additional consequence to it, for the establishment of some novel ideas, regarding the formation of veins as fully explained in the chapters on mineral veins, etc.

It appears from certain glacier and iceberg marks and deposits that the colder inhabitable middle latitudes have also been, at a not very remote period, much colder than now, and I think from increased area of dry land and the following reasons:

It is more than probable that the Earth was first cast from the Sun with its axis of revolution exactly at right angles, and that it continued so, long after arriving at and circulating in its orbit, as it would not become a natural magnet until sufficiently cold; but as soon as any magnetic force existed, one pole would be attracted a little more than the other (in similar manner to the magnetic needle) towards the centre of gravity and attraction of the Universe, thereby gradually inclining the axis and producing summer and winter. That such especially designed attraction exists is also proven by the fact that the distance of the Earth from the Sun is greater in summer than in winter.

If this is correct, the northern places which once had unvarying seasons have gradually obtained a summer's Sun, to dissolve and disperse the frosts and snows of winter and foster life.

The Carboniferous, or Coal Age formations, were also created and deposited much faster than we can imagine under existing circumstances, as the whole earth was once warmer than now, and the equatorial zone too hot for animals or land vegetables.

The waters and the atmosphere held in solution and suspension amazing quantities of lime and carbonic acid, which in a manner forced into life, and fattened, the organisms that flourished in the congenial warmth and continual moisture that overshadowed the alluviums of the steaming earth, and its tepid waters; so that, in proportion to the necessity for its removal, it was as speedily accomplished, and its oxygen released for the ample support of animal life.

"Prof. William F. Roberts says: The coal itself, even where it is most abundant, constitutes but an insignificant portion of the whole thickness of the carboniferous strata of the ancient coal formation. Most of the coal seams rest upon an under clay, containing stigmaria, the fossil rootlets of the plant called sigillaria. Professor Goppert examined the coal-fields of Germany and stated that he detected in beds of pure coal the remains of plants of every family, then known to occur, fossil in the coal. Many seams, he remarks, are rich in sigillaria, lepidodendra, and stigmaria, the latter in such abundance as to appear to form the bulk of the coal. In some places almost all the plants were calamites, in others ferns. In a cut for a railway in Lancashire, England, in the distance of 100 feet, six fossil trees were discovered, standing in vertical position to the dip of the strata, which was 15 degrees south. The roots were imbedded in an argillaceous shale underlying a seam of coal about eight inches thick. Beneath the coal seam and around the base of the trees more than a bushel of fossil cones, supposed to be the fruit of the lepidodendron, were gathered. In the carboniferous strata of Coalbrook Dale, and in other coal-fields, these fossil cones are met with, some of which are five inches long. One of the trees found in the cut measured 15⅛ feet at the base and 7⅛ feet at 11 feet, its discovered height. In the Newcastle, Bristol, and other coal-fields, these vertical stems are called by the miners coal pipes. These cylindrical casts of fossil trees now forming solid sandstone, after the coal is mined from underneath sometimes slide suddenly down and cause fatal accidents. The cliffs, known as South Joggins, on the coast of Nova Scotia, afford admirable sections of the coal bearing strata, containing fossils of the forests of the carboniferous period. Large trunks of trees are seen standing at right angles to the dip of the sandstone stratum, showing that they were, before this stratum was deposited, standing in an upright position; now they incline at an angle of 50 degrees from the vertical line. The vertical height of these cliffs is from 150 to 200 feet. At low tide a fine horizontal section of the strata is exposed to view on the beach. Lyell and Dawson, in 1852, made a detailed examination of one portion of the strata, 1,400 feet thick, where the coal seams are most frequent, and found evidence of root bearing-soils at 68 different levels, clearly showing 68 fossil forests, ranged one above the other, in this coal-field in the above mentioned thickness of strata."

The accompanying map of the Coalbrook-dale Coal-field, England, from the surveys and drawings of Marcus W. T. Scott, F. G. S., Mining Engineer, will very fully illustrate the actual present positions, and the varied shifts that have occurred since the growth and original deposit of these extensive coal measures. It exposes, to a remarkable degree, the wonderful commotion that then existed in a country that has settled into complete tranquility during the historical ages, and shows the differences of the consecutive intervening strata, as compared to the American measures.

During the subsequent and historical periods, the crust of the Earth had attained a sufficient thickness of cold and solid material to resist this hitherto irresistible side compression, that caused the first innumerable corrugations; then partial volcanic action invaded certain regions, to relieve the interior from pent-up gaseous elements, which, forcing out considerable fluid matter, through the few, somewhat distant, and restricted discharge-holes, these mountains arose, as the ejected matter solidified and built them.

The angulosity of the surface has been greatly modified since these water depositions, by the long continued and powerful actions of the winds, in the distribution of impalpable mud and sand, which by having the surface occasionally wetted by rains, it hardens into such palpable and permanent layers, as to sometimes closely resemble the actual water stratifications of the more regular formations.

> "And God said, let us make man, in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth."
>
> *Genesis*, chap. I, verse 26.

> "Thus the heavens and the earth were finished, and all the host of them."
>
> *Genesis*, chap. II, verse 1.

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*Those who may still doubt the effects of this lateral pressure, after the reasons given in these Chapters, should know that no other force can equal the side-abutting power of these vast spheroidal arches, as they edge down upon the *hotter*, and therefore *more contractable* interior globe, as it is not only *difference* of speed but *capacity for greater contraction*; and no man will deny that the *hotter* will contract *more*, within the *colder* and consequently, more or less, *hollowed shell*.

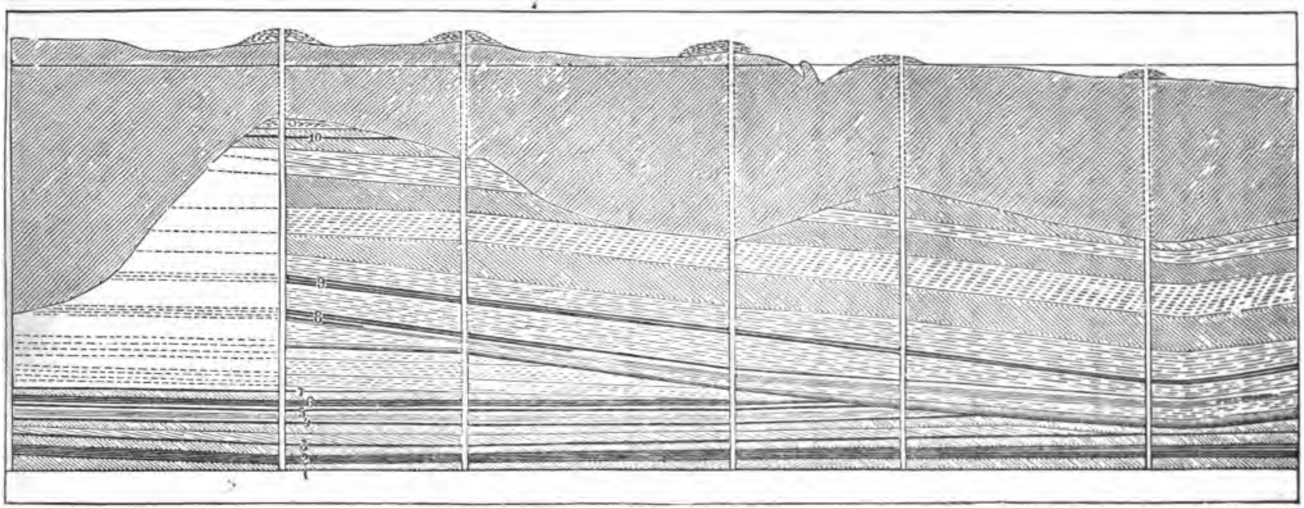
These vaults may, even now, be irregularly increasing under millions of square miles, until the colder and more rigid crust will again be so urged by *gravitation* as to *laterally crush and crumble* its side *borders*, for subsidence upon *increased rests* and over *less* of the underlying *non-supporting* cavernous areas. In other words, it is the constant struggle for equilibrium between the *single force, of gravitation*, and the *combined resisting and retarding forces, of side abutment and partial underlying and more or less solid, plastic and gaseous supports*.

In this thickening of the mountainous portions of the crust, the regular increase of heat with depth, of say 1° in 50 feet, would make the base-level of the Andes at least 300° and at only a similar depth beneath, more than 600°, so that plasticity would be sooner attained under mountains than elsewhere, and thus aid in the upper works of jumbled corrugations of the cold and crisp, surface crust, as the simple weights of the comparatively small mountains would be but mere feathers over such inconceivably enormous lateral forces.

Therefore, *when the size and consequent force of gravitation, of cooling globes, exceed their inherent strengths against lateral crush and transformation, a jumbled, metamorphosed and corrugated surface, will invariably be the visual result.*

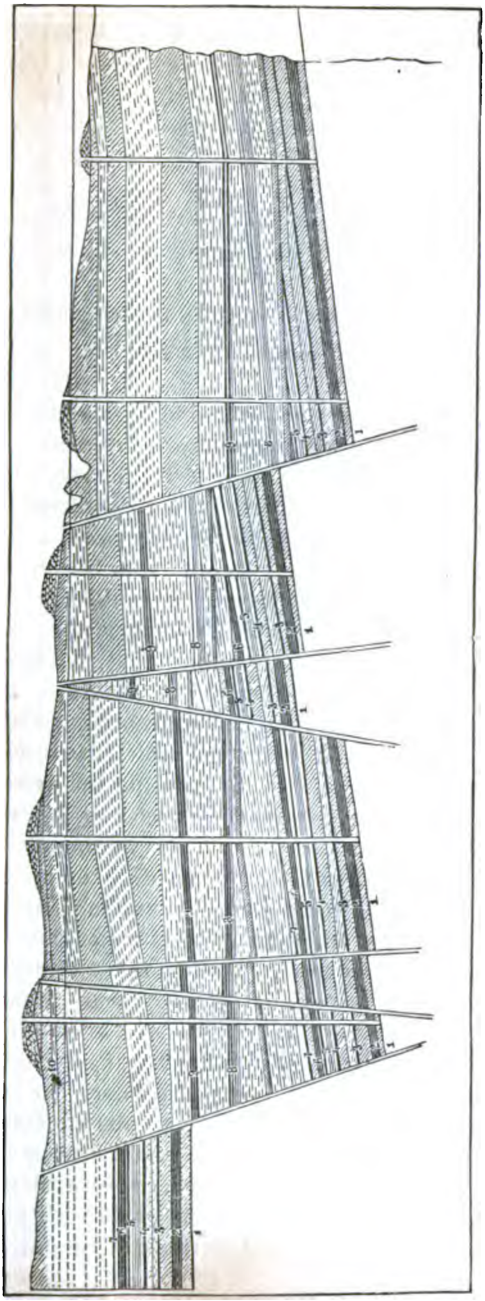
Hypothetical Section of the Strata and Original Surface Contours of the Coalbrook-dale Coal Mines, England.

The numbers show the original positions of the different layers of coal.



1. Little flint Coal; then hard rock. 2. Several seams (the Randle, best, two feet, and clunch Coal); then fire-clay. 3. Stinking Coal; then flint rock and iron stone. 4. Big flint Coal; then white and blue flat iron-stone clods. 5. Yard Coal; then yellow iron-stone clods. 6. Three layers of Coals (the double Coals, the double Coal rock, and half-yard Coals); then a bass and slaty measure. 7. Top Coal; then ball-stone (iron-stone) clod, rock binds, and clod, "calamincar" (the first persistent stratum above the principal Coal seams), rough rock, and Brickman's measure. 8. Clunches with Coals; then stony binds and rock. 9. Fire-clay clod and Coals; then stinking rock, clunches and rock-binds, thick rock, clunches and clods, and top rock. 10. Coal in the first (left-hand) shaft, with blue and red clod, and clunches; covered by red clay.

Actual or Present Section of the Coalbrook-dale Coal Mines, England.



The numbers show the present corresponding positions of Coal seams, as compared with the Hypothetical Section of their original depositions.

CHAPTER IV.

AURIFEROUS AND STANNIFEROUS GRAVEL DEPOSITS, ETC.—MODES USED FOR EXTRACTING GOLD AND TIN.

These deposits have been accredited to the ancient water-washed bottoms of rivers, but I will endeavor to give reasons, for placing many of them, at least, to the account of the more comprehensive disintegrations of débris as caused and concentrated under tidal actions and the surging waves of receding oceans.

It will be admitted by all close observers of mountain formations, that in many places of even extreme altitude, water washed pebbles and salt water shells expose every necessary evidence that the ocean has, at some remote period, overrun such portions of land, and therefore it would be absurd to suppose, that the effects of its disintegration and concentrations of the harder rocks, would not remain upon the slowly vacated declivities, intervening such high and dry portions and the present ocean.

The principal changes produced by such receding waters would be the breaking up and distribution of enormous quantities of the surface rocks of mountains by the dash of waves upon the shores, which the tides would naturally and continually convey to fill the creeks, basins, and plains, at lower positions beneath the water, near the sinuous coast. During this extensive crushing, an almost complete separation of the harder stones from the softer portions of the original bed rock would be accomplished, and the former, notwithstanding the water's crushing force, would remain at, and near the shore, as gravel beds, while the latter being softer and more impalpable, would be held in mechanical suspension and pass far away in the water to precipitate and re-form into much more extensive deposits of secondary rocks. The gold and tin oxide with platinum and similar metals, being heavy and permanent, would, under such agitation, soon settle to the bottom beneath the hard but much reduced boulders and pebbles of blue and white quartz.

Similar effects would be produced, as the water front, with much of its gravel, receded to the transverse spurs and foot hills of the mountains, and filled the submerged creeks and inlets with its débris.

Whilst this was being accomplished the various mountain streams would be also discharging gravel sand and mud into the ocean, which would be distributed along its shore by the surf, in somewhat parallel lines to the mountain itself; but as the water still receded over the almost level plain, this gravel would not follow it any further—because so very flat—and therefore, excepting the small quantity transferred by the mountain rivers, the gravel of this outlying and more remote bed must have been produced closer to where it now lies.

It will be most interesting to notice those natural and extensive parallels to artificial methods for concentration and collection of gold and tin for assay; as seen in the heavy water-worn washings from the alluvially formed gold and tin deposits of the world. The gold fields of California, which mostly lie upon the lower portions of the western declivities of the Sierra Nevada, may be taken as an example to show the general principle on which all others have been formed and washed into position; as every illustration can be seen here of such formations. This extensive, much distorted and corrugated frontage was once entirely submerged by the Pacific Ocean, and subsequently invaded in a somewhat irregular manner by various elevating and depressing intermittent movements of certain portions of the whole, by the powers created by nearer approach of subterranean fusion and irregularities from the Earth's contraction.

Now, we will suppose that the first upward motions were intermittent, and that a few thousand feet only of general elevation of the country changed height at once, whilst great variations of elevation would occur at some places as compared with others; and that, during this period of uplift, the gold had been formed, as suggested in Section I, Chapter VII, or in any other manner. During the long periods of comparative stability of the country, the rivers flowing from the higher grounds would, by disintegrating the various strata, wash the nuggets of gold thoroughly clean, and which, being much heavier than all the other débris, would be thereby concentrated, and remain on the front beaches or in the hollows and bends of the inlets, ravines and rivers until found and extracted by man.

Whilst this disintegration and concentration was being effected by rains, rivulets, and rivers, another *not insignificant* action was being accomplished by the powerful wash of the ocean on the ancient, but now elevated shore, as urged by innumerable gales, the breaking waves expended their gigantic strength on the crumbling strata, and which released the still remaining gold, boulders, pebbles, and sands.

Another uplift would form a second line of auriferous, pebbled shore; as would a third, fourth, etc.; and, lastly, that of the present hour, as the beach at Gold Bluffs, etc., etc.

The rivers that washed the gravel into the transverse courses towards these now terraced beaches, and the ocean, would be much less liable, *than such which were governed by height,* to materially change their *courses* or *positions,* unless compelled to do so by sudden intrusions of igneous overflowings, which doubtless sometimes prevailed.

If the ocean should again recede from the western slope of the Sierra Nevada, the Sacramento River would still flow through the "Golden Gate," or present river's mouth, in its prolonged course to the new embouchure into ocean; but the Seal Rocks, and serpentine beaches on either side, would be elevated to high and dry occular demonstrations of such change of level; which, however, would not be so clearly recognized if again buried by alluvium from ocean waters under repetitions of submergence and emergency.

All of these ancient beaches, inlets, ravines and rivers must have been, at a subsequent period, again overrun by the ocean for a very long time, and then more regularly elevated; for the whole labyrinth is now covered with varying, and in some places great depths of alluvium, that could not have been formed in any other manner.

The Sierra Nevada extends for some 400 miles in length, and has an average height of not less than 6,000 feet, opposite which these gravel deposits lie, and run in a north-northwesterly direction, through several large counties, at about 150 miles distant from and parallel with it and the sea-coast. The *greatest breadths and depths* of this belt of gravel lie *opposite the largest areas of* *mountain wash*, and it does not extend *much beyond either end*, as a river would have certainly deposited it.

It may be well to notice here, that during the Ages when these formations were being washed into position those "Tidal" waves described in the theories of Chapter V—as caused by subaqueous volcanoes and sudden subsidence of the ocean bed—would be much more frequent and powerful than now, and may have played a very important part, in forming and distributing the gravel, over the extensive flat ground, between the ocean and the mountain, as these terrific waves swept forward and backward over the shallow waters.

Too much has been credited to river bottoms, and crossings of the one over the other, with intervening alluvions; and too little to the more natural water-washed and weather-beaten sinuous shore of capes, bays, gulfs and creeks, across the ancient beaches of which the modern rivers flow into the ocean.

Transverse terraces of such are found not only here but in many other parts of the world where neither ancient nor modern river beds exist.

The general average north-northwesterly parallel bearing, and close proximity to the Sierra Nevada, the great length, breadth and depth, and consequently vast quantity of the gravel deposits of California greatly favor the idea of its being rather the mighty work of the ocean than a river.

The enormous gravel deposits fronting the mountains of nearly the whole of the North Pacific country, from Lower California to Alaska, and across the continent to the Atlantic, show that they cannot have been deposited by any river or rivers.

The gradual flowing or ebbing of ocean waters will also distribute gold or tin stone over the whole surface of a country, and leave those unmistakable evidences of such works in the shape of innumerable boulders and pebbles, amidst the auriferous and stanniferous sands.

Thus far, the ancient ocean waters had been disintegrating, rounding and distributing these deposits; but at some less remote period, volcanic fire played a no less important part, and disgorged an enormous amount of molten lava over a vast region extending for hundreds of miles in all directions from the eastern part of the State of Oregon. This startling outflow of lava must have proceeded from a vast fissure, as the quantity is almost beyond credence and volcanic cones are scarcely seen.

It appears that this molten lava must have run southerly just in front of the ocean, guided on the one side by the higher shore, and restricted on the other by the cooling effect of the water, and thus directed, it extended over the top of nearly all the gravel claims of California, as it is invariably present, either as a covering cap or amongst the disturbed gravel.

At a still more subsequent period the modern streams from the mountains have cut their seaward ways transversely through these beds of gravel and lava, and in many instances eroded channels, hundreds of feet deep, into the original underlying bed-rock, thoroughly exposing the various layers of lava, gravel and rock, for the miner's examination.

These fast running streams have formed, and are still forming and conveying, what may be generally termed, secondary right angled, or present rivers, auriferous bottoms; which are being profitably worked by different suitable methods.

It is probable that this ocean beach auriferous gravel alluded to was in position before many, if not all of the quartz veins were fractured and filled, for the reasons given in the chapters on veins, and that most of its gold never resulted from the veins.

Placer gold is found either lying on the surface or slightly covered by earth or gravel in higher positions than those deposits described, frequently on high benches, and even on the very tops of considerable hills, where it would be simply absurd to suppose that it had originated from veins.

For the above reasons, and the facts that veins are mostly absent, and do not contain the same kind, shape, or quality, or anything like a sufficient quantity of gold, for supplying that in the gravel, whilst platinum, and other infusible metals, also soluble in chlorine, are found in gravel deposits and never in veins, I think that most of this gold was either washed out from the mountains during disintegration, or has been precipitated from its chloride solution by sulphate of iron or some organic substance to aggregate upon the surface, and get rounded during the subsequent agitation of the gravel.

The alluvial "Tin streams" of Cornwall, England, differ from the "Gold fields" of California, in having very much less quantity and depth of gravel.

The oxide of tin from this source is always pure and very different from vein-tin, which contains impurities of sulphur, arsenic, etc. It is remarkable that tin is also soluble in chlorine, and is found in the alluvial deposits of Banca, where veins are not supposed to be present in the mountains.

See chapters on veins and the ideas on the formations of these metals.

MODES USED FOR EXTRACTING GOLD, OXIDE OF TIN, ETC.

The systematic means used for obtaining gold from alluvial formations will be fully described in the Second Volume of this work, on Mining and Metallurgy, but it will not be out of place just here, to show methods for ascertaining whether they are of sufficient value for being thoroughly mined. The Prospector's pan is a very efficient test for all kinds of gravel when used intelligently, and you may still further enhance its value by passing say the whole of a cubic yard of dirt through by repetition, and saving all the separate results in another vessel for collection by quicksilver, then burning and weighing the sponge of gold.

Either of the convenient methods alluded to in the following descriptions of the different classes of gravel mining, may be used for still larger and more exacting trials.

1. "PLACER MINING."—This is simply scratching the surface and chinks in the ground with pick and shovel and washing the gravel in pans, rockers, cradles, or flumes of various constructions. The gold is mostly found on hillside benches, and on the sides of mountain streams, and each day's work tells the result for profit or loss.

2. "DEEP PLACER MINING" BY DRIFTS AND SHAFTS.—This expensive mode has been sometimes adopted here, but much more frequently in Australia, where the gold lies near the bottom of the deep diggings, which have no drainage for water or discharge for waste rock, and the hydraulic system cannot be made available. The means is simple in manner, but difficult of execution, as skilled miners are needed for sinking shafts and driving, oftentimes dangerous levels, for the extraction of the remunerative gravel, which is drawn to the surface, and, if sufficiently loose, it is treated immediately by suitable water methods, and, if too compact, by battery. The mining, or rather the undermining part, is not unlike that for coal.

3. "River Mining"—Is accomplished in and by the river itself, in various ways, the most effectual being by ground-sluicing in the dry season, and what is called a "Wing-dam" in wet months. In the former, advantage is taken of the low water, so as to take the gravel from one part of the bottom, and ground-sluice it on another; and in the latter, the river is turned aside by the wing-dam, and the gravel taken from within its enclosure, after the water is bailed or pumped out, by shovelling the mass and that from the crevices of the bed-rock, and then concentrating out the gold under water treatment by the "Hand pan," the "Rocker," or "Cradle;" and by the "Long tom" or "Ground-sluice," when side water is convenient.

The living rivers, or those now running westerly to the ocean, were first worked, and in following them up-stream, this immense transverse zone was discovered, but passed through without much examination, as they still followed the rivers to the foot-hill gulches, of the mountain, and then to the side benches, which, when they could be worked by water, were often found very profitable. As the rivers became exhausted they fell back on the gravel at the sides, and introduced better and more rapid washing appliances, and thus they progressed step by step to increased numbers of workers and larger operations, until these rich places became scarce.

These immense zones of gravel were tried next, more from necessity than desire, and found to be rich enough, in many places, to pay by shafts and drifts after the Australian method just described, and then the hydraulic system was cleverly used, and much that would not pay before, by the aid of capital and this much cheaper mode, produced still larger profits.

4. "Hydraulic Gravel Mining."—This really magnificent system for the rapid and economical disintegration and displacement of immense beds of more or less concentrated auriferous gravel, was first devised and practically applied in California, but I regret to say that I had considerable difficulty in obtaining the name of the man, as he (like Marshall and Comstock—the discoverers of gold in California, and silver and gold in Nevada) has been sadly neglected by those few whom he has directly enriched, as well as by the millions of his fellow-men indirectly benefited by very determined and useful energy and practical

skill. I am informed by Mr. R. R. Craig of San Francisco, that Mr. Edward Mattison was the first to apply the power of water for such a purpose under a sixty-feet head of pressure, as passed through a small nozzle of at first only three-fourths of an inch in diameter, on a gravel bank at the American Hill Mining Claim, situated about one mile west of Nevada City, Nevada County, California. Mr. Craig succeeded him, and has been more or less engaged in similar operations since that time.

The manner of applying this means for disintegration and discharge of gravel and retaining the gold is as simple as it is cheap and effective, and without it millions of dollars would have remained *in situ*, under low grade gravel, for ever. Conducting pipes are now sometimes used of three feet diameter, discharge nozzles of ten inches, under a head pressure of from 100 to 300 feet, and thousands of miles of water ditches convey powers for hundreds of claims. The following natural facilities are necessary for complete success, and should never be despised:

1. Sufficient amounts of gravel and gold.

2. An ample quantity of water with adequate fall.

3. That the water can be brought to the ground at a grade of not less than nine feet per mile at sufficiently moderate expense.

4. A good run or fall and space for the discharge of "Tailings;" or if an artificial "Bed-rock" tunnel can be excavated to command another better natural outlet for ensuing successful development by more rapid discharge of waste, through not less than a four per cent. grade of descent, to a convenient site and suitable fall into a basin or valley beyond, for receiving tailings or waste débris.

5. That the gravel is not too much concreted or solidified into tough cement or has an excess of large boulders which must be passed aside by hand or broken smaller by blasting powder for running away through the sluices.

6. The best paying claims vary, very much, in the mode of occurrence and quantity of the gold in the gravel, some having about two cents at the top and about a dollar per cubic yard, at the bottom; others have it all near to and upon the bottom.

CHAPTER V.

NEW THEORIES FOR EARTHQUAKES, ETC.

Many theories have been suggested for the cause of earthquakes, and that of compressed steam—as created by high temperatures, in confined cavities—suddenly finding vent, has been generally most favored.

It is not my intention to expose this, or describe the many others; but, as I cannot see that they could cause such peculiar motions and effects as we have been but too familiar with, I will offer some new theories, which appear more consistent, for the sudden presence of such powers, the astounding motions created, and terrible effects produced.

First Theory.—In Chapters I and II, it was argued that a sphere of the size of the earth, would first solidify at the surface, and that many extensive portions of the earth's outer shell are actually arching over immense subterranean vaults above the inner globe, which may have numerous volcanoes with rivers and lakes of lava. Some of these may discharge from continual outlets, whilst others would, at this depth, occasionally burst forth with amazing strength, and hurl immense quantities of lava upwards, to strike the interior of the upper crust with sufficient violence to produce what are termed earthquakes. Now, the Andes and many others of the highest mountains have had their very summits studded with volcanic peaks, and it is well known that some of the more extraordinary throes of high surface volcanoes have discharged thousands of feet above their apices, and covered extensive countries with their diminishing rocks and debris; so that should this deeper and much stronger power be applied under an irregularly shaped *stalactitic* hollow sphere, the central upward motion, so often noticed, would be first felt by the transmission of the blow, in a straight line to all points, as proven by ordinary concussion; whilst the wave would diverge with varying undulations of this comparatively thin, unsupported and more easily shaken shell. A quick repetition from this same centre would create a similar wave, whilst other craters of the vicinity, would at times burst forth simultaneously, and create the cross or conflicting waves sometimes noticed, when monuments and chimneys are twisted: or this varied action may be produced by several subterranean peaks bursting out, urged by the more profound common power, and from their difference of elevation or speed of discharge, would strike at slightly different times and *slopes*, during such general bombardments of the outer *stalactitic* shell or surface crust of the earth.

This would have produced similar effects to the severe surges, of forty seconds' duration, and those that intermitted for several days at San Francisco, in 1868. It does not follow that because some large vaults exist, that all the interior should be thus vacated; for such cannot be so, as the daylight volcanoes do not act together, unless in close proximity. It is probable that these hollows are mostly formed between the subterranean rests of the mountain ranges and the gradually subsiding ocean beds and extensive plains.

This theory possesses the advantages of tangible practical agencies which are known to exist, and conclusions founded upon substantial reasons. Volcanic action, once much more general at the surface than now, has naturally retired with decreasing temperature to its more suitable subterranean regions, to discharge into these vaults, leaving but a few external escapements, in the form of long dormant volcanoes; whilst others still discharge from the solid supporting points of the active volcanic mountains, through especially direct passages which communicate with the deeper interior.

It is now about thirty years since that I had the good fortune of being on the upper cone of Mount Vesuvius at night, when its volcano was under comparatively slight action. We desired to see all that was possible, and ascended the upper cone to the very brink of the crater, which was then about fifty feet in diameter, with a red-hot lining. We stood on the hot rim of its marginal basin, which was about 100 feet in diameter, and, knowing what to expect, placed ourselves on guard and awaited the result, during a few minutes of deathlike quietness; when suddenly the mountain belched forth a terrific sneeze, accompanied by many junks of irregularly shaped plastic lava of from the size of nut to that of horses; most of which, after having ascended in a kind of fiery fountain, spread out and fell on the circular margin, and which we dodged by jumping aside, but others, being too heavy, just appeared above the orifice and fell back again.

We waited for more of similar character, and again jumped aside from the falling masses, but after a little while the mountain gave such a terrific sigh that we scampered precipitously down the side of the cone to our guide, who had advised us not to go up, and stood laughing at the base on an annular horizontal space at the head of the lower cone, whence the lava ran down for miles on the other side of mountain. These terrible gusts were irregularly intermittent and lasted only a few seconds, being nothing short of explosions. The action of the mountain was, of course, comparatively mild at this time, or it could not have been ascended.

All volcanoes discharge more or less steam, and it has been therefore supposed that proximity to water is a necessity of their existence, but the very *rims* of the oceanic basins *where they generally obtain outlet beyond its cold bed, have been, and are being formed*, by that same compression which creates and sustains their heat, whilst the hydrogen of this water may have proceeded from the interior of the Earth, where under sufficient pressure it probably lies in liquid or solid state until it is by some means removed, to create—by its explosion—even the *ejective power*, whilst the actual water from this internal source—derived just like that of the ocean itself—was but the *product of combustion* with atmospheric oxygen, at or near the orifice.

Since the first edition was published, where this was alluded to, the spectrum has proven that *explosions* of burning hydrogen, are of frequent occurrence in the sun, where its peculiarly colored flame is seen to shoot *out and upwards* in vast volumes for scores of thousands of miles; which is a perfect demonstration, that hydrogen must be a heavy liquid or solid under suitable conditions; for when freed it becomes the lightest of all the known gases, and could not in such a state, *descend*, so as to burst, in this peculiarly wonderful manner, from *beneath* the burning mass of the sun.

The fact of the existence of such hollows is least substantiated; but every thinking man, who has been accustomed to earthquakes, must know that such undulating waves as accompany severe shakes cannot be produced on a solid sphere, and that it is simply absurd and contrary to the observations and laws of contraction, even on a small scale with single homogeneous materials, to suppose that the still red-hot nucleus has ceased to contract because its surface is cold and solid. No man who credits the igneous theory can doubt that a hot interior of nearly 8,000 miles diameter has contracted during refrigeration, and that, like smaller metallic globes, the surface becoming cold before the interior, the extent of such cavities would be proportionate to the sizes of the contracting bodies.

(See foot note at page 20.)

The following statements will favor this theory: "About twelve months since there was a heavy rain of ashes and cinders along the northern coast of Norway, covering the ground several inches deep. Investigation revealed the fact that these strange materials, coming from a northwesterly direction, like immense clouds through the air, were of volcanic origin. It was at once thought that there must have been an eruption of Mount Hecla in Iceland. A steamer was dispatched from Copenhagen, and that vessel returned from Rejkjavik, with news of an unparalleled disaster. It seems that the outbreak began on Christmas, and has continued since, with scarcely any interruption. For seven weeks before Christmas the inhabitants were terrified by subterranean noises like thunder, which extended through nearly two-thirds of the island. Early in January earthquakes proceeded from all directions, and at last an old extinct volcano, near Vatrayskud opened, and for four weeks continued to eject immense quantities of liquid fire, lava, ashes, and a boiling hot muddy fluid. The village and smaller hamlets and farms within a radius of twenty miles were all destroyed, and over a thousand people had to flee for their lives.

"After four weeks this volcano ceased, but at that moment another extinct volcano, nearly a hundred miles away, near Myvatu, sent its burning mass upon the peaceful habitations around. This eruption lasted for several weeks. The village of Myvatu became a prey to the fiery elements, and the whole country for more than 50 miles was devastated. More than 800 of the people are reported as having been rendered homeless.

"Ten thousand people are said to have lost nearly all their possessions, and the remainder, who live nearer to and among the coasts, some forty thousand in number, are themselves too poor to support such a vast number of needy people. Several hundred persons are also reported to have perished. The world renowned Geysers have dried up since the terrible eruption began, and instead of water, these mysterious funnels emit immense quantities of hot smoke and ashes, which, during the night, rising several thousand feet into the air, appear like gigantic columns of flameless fire, visible for hundreds of miles. It is said that no historic record of any volcanic eruption anywhere in the world compares with this, either in territory over which it extends, the number of newly-opened craters, or the time of its duration. The Copenhagen Government has issued an appeal for aid to the sufferers."

Although this first theory suggested may account for the frequent strong actions, which occur at places, where the volcanic agencies are most concentrated, I am convinced that another principle of action must cause the *isolated shakes* which are occasionally felt, in all formations, throughout the world.

SECOND THEORY.—Based on the following axioms:

The surface is colder than the interior.

Difference of temperature cannot exist without corresponding inequality of motion, during general contraction, as produced by refrigeration and gravitation, and described in past chapters.

This unequal speed of shrinkage of sections in contact, must produce great compression, violent jarring, with much friction, and consequent increase of heat at such places.

In the first, second, and third chapters of this section it was demonstrated, that the gradually cooling globe would first solidify at and near the surface, and that the hotter more plastic and molten interior, in lessening its diameter, would leave this shell to resist the enormously powerful action of gravitation. This internal support being thus removed, the rocks of the crust were insufficient to bear the prodigious side pressure thus created, and the solid surface crumbled, or became under pressure again plastic, at the lines of least resistance where the corrugations of mountains and valleys were formed, so that such enclosed surface would then settle down to rest on the 'erior as before, until a repetition ensued. Now, in modern times, this shell has become so thick that it almost sustains itself, although slight changes are still occurring, and at very remote intervals of time, more calamitous subsidences may yet greatly astonish mankind.

Before entering upon the particular principles of this second theory, you should in addition to the above effects of apparent upheaval and *actual* subsidence, produced by contraction and gravitation, fully understand *another resultant motion*, which must have always occurred at the moment when the mountains were suddenly forced into shape by the surrounding lateral pressure; which is that of the *equally sudden movement* of the unchanged *adjacent country and its mountains, towards* the aggregated and thickened compressed mass of *new mountains* thus formed. The total extent of this *circumferential* motion will also be more than thrice that of the *diametrical* contraction of the interior.

With these facts before us, we will suppose that at a suitable depth, where the rock has also solidified, an inner hollow globe is now undergoing similar changes from contraction, etc., and forming subterranean mountains; so that when a mountain range is thus crushed and thickened by this astounding power, the adjoining side ranges, by advancing towards the crushed plastic mass, would rub violently against the irregular stalactitic interior of the outer shell, and thus produce the peculiar side sways and oscillations of earthquakes.

Other consequent effects of this pressure may be, *the creating and sustaining volcanic heat, and causing the metamorphism of rocks.*

THIRD THEORY.—It has been stated at the commencement of this Chapter, that *steam suddenly finding vent from confinement under great pressure in cavities* has been favored by scientists, as the leading cause for earthquakes, but I am not aware of any one having yet expressed the following ideas, also indirectly dependent on confined steam, but from the entirely different cause, *of instantaneous condensations occurring beneath those portions of the surface of the earth underlying oceans and inland seas.*

It has been, for various reasons, strongly urged in this and preceding chapters, that many extensive chambers must naturally exist, at no great distance beneath the surface, and that such would, for reasons also given, more generally lie in front of mountains and under ocean beds or extensive plains.

We have had many instances, in our time, of the ineffectual struggles and actual facts of sub-ocean volcanoes really overcoming the vast cooling effects of even deep water, and building up large islands above its surface, and therefore no one can doubt that occasional craters or discharge holes are sometimes suddenly formed in the bed-rock of oceans and seas. The above facts being true it is certain that the deep water would descend, under its high pressure and rapidly condensing influence, with lightning speed, into the underlying vaults, and create, by this vast injection of water, an almost instantaneous relief of pressure, by vacuum, and a consequent shake of the hollow spherical crust. The condenser of the steam engine receives its water under far less powerful and effective circumstances.

FOURTH THEORY.—" Tidal waves," or those occasional but most destructive swells from the ocean which have sometimes devastated coast regions, may have been caused by the *eruptions of subaqueous volcanoes suddenly uplifting the overlying water and propagating wave-circles in all directions*, for, as stated in the last theory, the pent-up forces, after making many sub-ocean stifled attempts, would be ultimately forced beyond to the dry margins to find exhaustive vent; or the sudden throes of the Earth's crust as produced by subaqueous "earthquakes," may, by lifting portions of the surface, propel diverging waves to, less remote, coasts.

FIFTH THEORY.—Some of these, so called, "Tidal waves," may have been also produced by the *sudden subsidence of comparatively small areas of the ocean beds*, causing the *immediately overlying water to drop thereon*, thus favoring a *concentrating rush of the surrounding water*, to rectify the *original surface level*, which after first forming *a mound of water over the spot*, would *propagate, by reaction*, circles of waves in all directions to opposing shores.

Note.—SIXTH THEORY. " Volcanic force "—Volcanoes may not only have been created, as previously suggested, by the friction and heat from enormous lateral pressure, as caused by the plains and ocean beds persistently *edging* their ways down, but the force for discharge may be also derived from these small but frequent intermittent settlements; a when an enormous quantity of rock gravitates in *one solid rigid block*, or mathematical un *of weight*, and *just overlaps* [or *jams laterally against*, a small *fractional area* of gaseous, liquid, or plastic matter, this excess of power would force it rapidly through any connected crate and high in air beyond, even when of equal or superior specific gravity; just as when th *end* of a *large* " Flagstone " is laid upon a *small* and yielding rubber ring properly placed onnection with a suitable tube, containing liquid mud, or even mercury. These elas sts may also be caused by the almost instantaneous oxidation or combustion of a v

CHAPTER VI.

FORMATION OF "TRUE FISSURE VEINS" IN THE AZOIC AND METAMORPHOSED PALEOZOIC ROCKS—OF CONVERGING OR WEDGE VEINS IN THE CONVEXED UPPER SECTIONS OF UPHEAVED BED-ROCK—OF VEINS THAT ARE MORE OR LESS CONFORMABLE TO THE GENERAL CLEAVAGE OF THE TILTED STRATUM, IN THE SEAMS OF WHICH, GANGUE, MINERALS AND METALS, HAVE BEEN DEPOSITED—OF VEINS THAT INTERVENE AND SEPARATE DIFFERENT STRATA, AS GRANITE AND SLATE, OR SLATE AND LIMESTONE, ETC.—OF GASH VEINS, CROSS-COURSES, SLIDES, DIKES, CARBONAS, BONANZAS, POCKETS, AND FLOORS—OF IRREGULAR SUBLIMATIONS, ALLUVIAL DISTRIBUTIONS, AND SEDIMENTARY DEPOSITS.

TRUE FISSURE VEINS.

The formation of fissure veins is as much exposed to speculative theories as earthquakes, and even more difficult for solution. Although it appears probable that many of the true fissures were formed by the repeated violent concussions called earthquakes, yet so many stumbling-blocks obstruct argument, that it appears impossible to proceed from this cause to the various effects produced, in the extensive systems of mineral veins.

It is easy to account for one fissure being formed in front of a hill or mountain, in a line of least resistance, or even on the more regular plain, which has been thus accomplished in our day and locality; but when the ramifications of a very numerous system of veins are exposed before us, with their ever varying sizes, directions, dips, angles and spurs, intersections and crossings, both lineally and vertically, as they lie in strata, it is almost impossible to explain this labyrinth of wondrous formations.

It is probable, that as so many of the systems of mineral veins are situated in low fronts of mountains and hills, that such mountains, by continuing downward to the interior, as previously described, may, by *forming the solid margin* to the subterranean hollows under the surface plains, create fissures at this hinging point, during the action of waves produced by earthquakes, as they fracture on arriving at the mountainous shore.

Again, it may be that similar waves, proceeding from a more oblique centre, may have produced the diagonal veins and cross-courses; whilst the settling of the mountain during these shakes, from its superior weight, created the slides; and the direct upheaval of igneous power, exerted immediately below, caused the fracture and filled the larger dikes with igneous matter.

These powers would also facilitate the following effect:

Referring back to my theory of the *ocean-beds or plains sinking faster*, instead of the mountains being upheaved, I see no better cause for the formation of veins than *that fact*, for the *subsidence* of the outlying plains *could not occur* without a *simultaneous, transversely angled fracture* at the *centre of motion and weakest points* just in *front* of the mountains, where fissures would be the reasonable result.

This theory bears no resemblance to that of Werner, who thought that the mountains, and their immediate sides, may have settled unequally *during hardening*, from the *aqueous* formation of the strata.

My theory is founded on the idea of hard rocks being fractured by the enormous *leverage* of side weights from subsidence of plains or ocean beds, which may extend many thousand miles away in all directions.*

Another probable cause for the formation of systems of lodes, etc., suggested by the presence of igneous dikes, metamorphism, and the numerous veins, with the crumpled and crushed appearance of the rock of such sections, may be illustrated by supposing that a second heating of the cold and solid crust occurred, as caused by enormous lateral pressure of the earth's surface, just at these places, or from the near approach towards partial invasion of this particular portion of the surface by subterranean heat; for as the expansion caused by heat is unlimited, and all side extension was prevented by surrounding rock, *the warmed portion would occupy the same space as before*, and would shrink on cooling, in proportion to its extent and degree of warmth, to

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*These new theories for the formations of *mountains, plains, and veins*, by difference of subsidence, and consequent fracture close to the thick and strong mountain hinge, joint admirably together; and I see no better causes for explanation of how they are fractured, and why so often, in such positions.

form the various fissures, as large or larger below as above, and account for other differences in the appearance and crystallization of rocks, peculiar to such districts.

In this proposed theory, which I now advance, the after expansion would be the ruling power in the formation of fissures; and, consequently, at the time each vein was fractured, the line of contraction would be at or about right angles therewith, and the variation of the position or extent of this second heat would, by causing different lines of expansion and contraction, form various fissures of correspondingly different bearings to those previously created. Earthquakes would only assist and modify these results.

This principle of the *second warming* of certain *spots* of the hitherto *simultaneously cooling* globe, has also been a leading power in upheaving whole districts of mounds and mountains in volcanic regions; and, in such positions, the contractions have also produced veins during the second local and more speedy refrigeration; but the rock is of the wrong kind, or the base mineral elements are too much scattered and sealed by fusion, to be present in the veins, for the subsequent precipitations from the collecting solvents, as in the more ancient metalliferous strata.

Veins have been occasionally fractured at the lines of least strength, by earthquakes, and opened by recedence of the outlying flat from a mountain's frontage; at other times, by fracture and subsequent divergence of the walls, as the rock was convexed during the uplifting of hills over igneous action, and by independent fractures which may extend for miles; but such formations, either from want of age or traversing modern strata, have seldom produced profitable quantities of the base minerals. These three, last explained theories, are more satisfactory to me, than any heretofore, and they also conform to my other notions for creation of volcanic and metamorphic heats, by extreme lateral pressure, caused by the enormous lateral force of the earth's crust on itself during the irregular speeds of subsiding travel of the mountains and plains toward the centre of the globe.

CONFORMABLE, CONVERGING, WEDGE, OR "SEGREGATED" VEINS.

These very numerous and universally distributed veins lie between the divisions of stratified rocks, as gneiss granite, clay-slate, etc. They are seldom of great length or size, and are always unreliable, as the wedge like space between the walls of the cleavage of the upturned stratum, must necessarily diminish by becoming *flatter* and *closer* in depth.

In gold and silver regions, with other conditions, they contain gold and silver, but are generally worked at a loss, when *strictly conforming* with the *divisions* of the stratum.

The largest and by far the most profitable veins are those formed by more extensive contraction, which by acting in a direction at right-angles to the general run of the mountain, or spur, (that caused the tilting of the slate,) fissures have been suddenly consummated by subsidence assisted by earthquakes; such veins are, also, conformable to the cleavage of the stratum for short, suitable distances, but take a separate path in those more general sections that deviate in direction or dip from the lines of least resistance at the moment of fracture. That is, the plane of the fracture caused by subsidence and shake, although frequently swerved by cleavage, would invariably return to its own original course when more direct, which *would always be the richer paying* section of the vein, because it partook more of the principle of true fissure, and not only was enriched by the numerous feedings of several of the divisions of the stratum, during its diagonal passage, but it consequently held its size and quality for greater length, and depth. Too much consequence cannot be attached to these facts by the gold and silver quartz miner; for even here the advantages derived from deep and extensive fractures, which resemble the true fissure system, are most readily seen by comparison.

Another example of converging or wedge veins would be where igneous action uplifted a small area, so that an originally flat piece of country became convexed at the surface, when consequent fractures would necessarily form diverging walls from the centre of action, which were thus filled by sublimation of the oxides of base minerals and the deposition of various subsequent compounds.

In such cases both the actions of divergent separation, and the after contraction of the warm district, were in power, and therefore the depth and size varied, with the distance from centre of motion. A remarkable illustration of this may be seen in the small foot-hillocks fronting the Trinity Mountains, rabia District, near Oreana, Humboldt County, in the State of

Nevada, where there is quite a system of such veins, which contain large quantities of argentiferous lead and antimony.

OF INTERVENING VEINS BETWEEN DIFFERENT STRATA, IN CLOSE CONTACT WITH EACH.

It frequently happens that one stratum, or dike, or broad channel of rock, recedes very gradually from another, by force of contraction or settling of the adjoining plain, and the intervening space, in old formations, is afterwards filled with quartzose or other gangue, whilst the mineral components are obtained from the adjoining strata, and deposited by infiltration; or, when overlying igneous rocks, by intrusive action and sublimation, modified by after solvents and precipitants.

In "True fissure vein" districts, such are more generally despised than wrought; in fact, the more effective, deep contractive action, that produced the true fissure veins, has, by thus using up this power, almost entirely prevented these formations. In numerous instances, where compact primitive rock mountains slope at a steep, regular declivity, and are fronted by broad belts of porous metamorphosed rock, a partial decomposition of the rock ensues, when probably the released alkali, being carried with the water to the more solid face of the mountain, meets and precipitates the minerals upon this water-tight foot wall.

Silver and gold have been sometimes found in such positions, in very profitable quantities; but, for reasons that will be explained in chapters devoted to these subjects, although the vein will attain considerable size, it will possess no upper wall, or will the foot wall be regularly well defined, or the vein produce sufficient quantities of base minerals to pay profits, to large mining companies.

GASH VEINS.

This class of veins may be found in all sedimentary deposits, and may be compared to the ordinary cracks that are to be seen in dried or contracted mud-beds, which over-lie another different formation. They are caused by directly local shrinkage of the single stratum, as it dries or hardens by natural warmth of the atmosphere, or is baked by underlying igneous influence.

Although each successive layer of particular stratum may be separately fissured, the veins never continue (unless by chance) from one stratum into the other, or extend for any great distance; so that profits should be expected more from the number of such than from a single limited vein. Thin floors, or horizontal seams of mineral, generally prevail in the divisions of such stratum which frequently increase the supply.

CROSS-COURSES

Are transversely fractured fissures, of more recent origin than the regular veins, on which those previously formed necessarily slide, to accommodate the varied contraction of the country that contains the whole system of veins, cross-courses and slides. They are, though poor and uninteresting within themselves, advantageous feeders for the mineral deposits of regular veins.

Near the copper and tin veins of Cornwall and Devonshire, when in clay-slate, and more than one mile from the granite, the best lead mines are generally found, in cross-veins.

SLIDES

Are still more recent fractures, very uniform, and of smaller size than "cross-courses." They contain more clay, with less quartz and mineral, and are not so extensive.

DIKES

Are different to all these; generally much larger, and chiefly composed of a yellow or blue-colored feldspathic finely crystalized igneous rock, and although they have had a marked effect in mineralizing veins, they now contain little or none within themselves.

CARBONAS, BONANZAS, POCKETS, FLOORS, AND DEPOSITS.

Carbona is a word much used in the west of Cornwall, for pockets of tin ore that are found on either side of the lodes in the adjacent country rock, which are connected with the otherwise mineralized veins by very small strings, vughs, or branches, which enlarge suddenly to form the carbonas. The expression is confined to such positions, and to the more compact bodies, as offshoots from an otherwise generally mineralized vein; and not to branches, isolated pockets, or separate deposits.

Although such have been found all over Cornwall, they are more particularly displayed in frequency, size, and riches, in the districts of St. Ives, and Lelant; where the otherwise moderate ordinary profits derived from the lodes are sometimes increased to an extraordinary degree by these carbonas.

These districts may be considered one, as they lie connectedly on the northern, eastern, and southern slopes, of a granitic crescent, formed by the several small mounds, Knill's Steeple, Rosewall, Trencrom, and Trink Hills.

At the eastern end of Rosewall Hill, the Rosewall Hill Mine is situated, and these veins continue east into the St. Ives Consols mine, which has yielded large profits from the principal lode, as frequently assisted by numerous extraordinarily extensive ramifications of small but rich net-work veins, and these carbonas. One of the latter, happening to be under the house of a poor man, the dues (of probably but one-eighteenth of the total value) placed him suddenly in luxurious circumstances. These veins then pass through Wheal Trenwith into the sea.

The next celebrated carbona mine is the Wheal Providence, on a parallel lode, situated about one mile south from this, which runs from Knill's Hill into the sea; their profits and market value having been repeatedly influenced by similar discoveries. The flanks of these hills have been much broken or crumbled, and the rock adjoining the veins, is often found either decomposed or decomposing.

The *Bonanzas*, of Mexico, are also unexpected prizes, having a similar but more extended meaning in mining, as they apply to all positions in stratum, both when attached and when detached from veins, and are much more important for gold and silver, as less space will contain considerably more value.

Pockets lack veinous appearance and continuance, are of irregular shape, and occupy all positions away from veins in the country rock.

Floors differ from these by filling the spaces left between horizontal faces of stratum, or strata, and are often very extensive, and valuable, more particularly for coal, and iron ores beneath the coal measures.

Deposits are such as must have been concentrated by the sublimation, alluvial* water-washing, infiltration, or precipitation of considerable quantities of minerals, on a certain spot, or into a suitable receptacle of bed-rock.

Those of sublimation would apply to the volatile and condensable minerals, as the deposits of cinnabar at the New Almaden and other Quicksilver Mines of California and elsewhere, which make in steatitic channels, dikes, or zones of rock, and not in proper veins; and the sublimations of lead and antimony at the Montezuma Mine, already described.

The alluvial deposits are the oxide of tin, and the gold, platinum, etc., of placer and gravel diggings.

Those of infiltration and precipitation, will include all such as must, from the peculiarity of their bed-rocks, have been thus deposited.

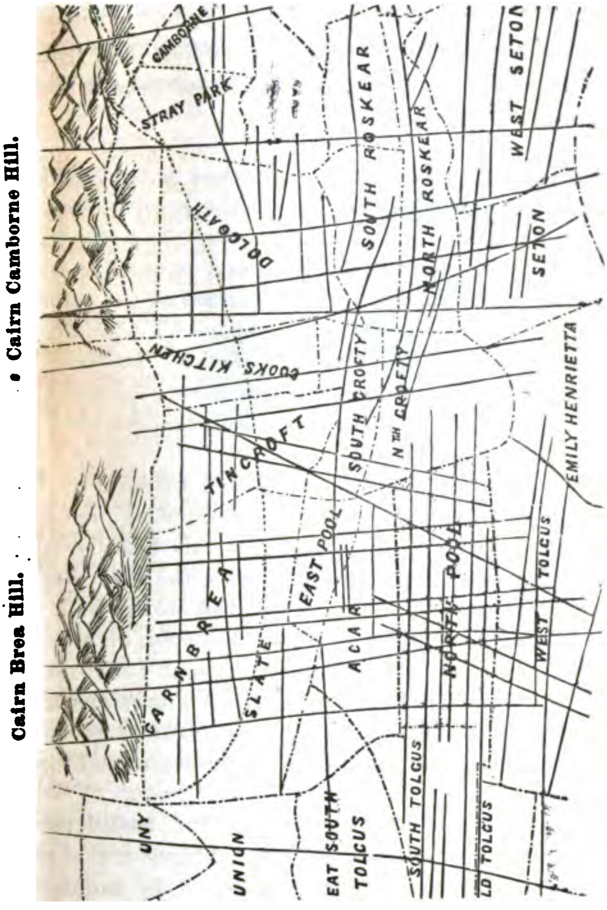
The sedimental deposits will be generally found in horizontal layers, underlying, and more or less conformable to, the coal measures, as iron.

There is still another class of veins which must not be forgotten, as they are equally well defined, and crop but too boldly, as *embossed burlesques of all serious consideration of this subject*; reminding us that man's knowledge, of even the inanimate creations of the Supreme Architect of the Universe, is limited.

I allude to the veins, angles, and spurs; deflections, comparative bearings, and dips; junctions, intersections, and variations; contractions, enlargements, and pockets; cross-courses, elvans, dikes, and slides; with every variety of heave, shift, or slide, which are also present in those wonderful miniatures of the larger systems of veins, so frequently seen in the small water-washed boulders taken from the pebbled shores of suitable formations of all ages of rock, as well as similar miniatures in small stones extracted *from* veins. These could not have been formed by any means yet suggested, and it must be admitted that the law is utterly unknown that governs the creation of such minute *fac similes* of lodes, cross-courses, dikes, and slides.

Silicic acid, and all the components of the other gangue stones, appear to be urged by some subtle power to aggregate and precipitate from solutions in ramifications with bed-rock matter, and on this small scale, to a much more general extent than in true fissure veins; and the question arises, whether or not the principle extends through all the intermediate stages from the small to the large scale?

If contraction of the surface is the fabricator of small and large fissures, why are the intermediate stages not thus interlaced by fissures in similar rock? Again, why should the true fissure districts alone exhibit this phenomenon on the large scale, whilst *all kinds of veins* show, more or less, these features in *small stones*, taken from such veins? It is possible that the deep-seated fracturing power peculiar to the true fissure system, by allowing greater freedom for more equal settlement, may thus arrange its veins to resemble these miniatures in this particular, and that the remaining laws may work differently in small stones of veins and country.



THE VERY RICH SYSTEMS OF COPPER AND TIN LODES, SITUATED BETWEEN THE TOWNS OF CAMBORNE AND REDRUTH, CORNWALL; WHICH LIE IN THE SHALLOW CLAY SLATE FRONTAGE OF THE CAIRN BREA, AND CAIRN CAMBORNE GRANITE HILLS, AND CONTINUE DOWN INTO THE GRANITE, THAT IS THUS SUBMERGED BY THE SLATE.

THIS DISTRICT YIELDS COPPER TO ABOUT ONE THOUSAND FEET DEEP, THEN THE COPPER LESSENS, AND TIN IS FOUND IN GREAT ABUNDANCE BELOW. IN OTHER PARTS OF THE COUNTY THIS IS REVERSED.

CHAPTER VII.

THE SUPPOSED ACTIONS AND REACTIONS THAT HAVE BEEN AND ARE CONTINUALLY TAKING PLACE IN MINERAL VEINS, POCKETS, AND DEPOSITS—HOW MINERALS WERE FORMED—HOW GOLD, PLATINUM, AND SIMILAR METALS, WERE FORMED.

In the consideration of these subjects, we had better start from the period when the *base metals*, and even the *precious metals of to-day*, were chloridized or oxidized by *immeasurably long* fusion and refrigeration, in presence of chlorine and oxygen from the atmosphere that surrounded the red-hot surface of the earth, as described in Chapter II. On referring to page 23, Chapter I, it will be seen that nearly half the weight of the "bed-rock" is oxygen, still leaving a surplus in the atmosphere, and that these lighter metals and oxygen formed the entire primitive rock surface of the Earth.*

Thus, everything of a fixed character was an oxidized or chloridized metal, of low specific gravity. General ignition, and long-continued natural causes, have produced, on this massive scale, precisely what might have been expected from the every-day experience of the chemist; and fire supplied the world with similarly simple compounds—the oxides and chlorides of metals—which were more or less distributed throughout and over the primitive rock formations, thus providing for the more diversified future developments, when general reactions resulted at appropriate times, under suitable conditions of pressure, and consequent temperature.

Another favoring reason for this is, that the useful metals, being all much heavier than those that formed these rocks, could not have reached the surface, unless lightened by union with oxygen or chlorine into volatilizable states. None of the metals that immediately concern the miner (although their affinities for oxygen were equally strong) formed such permanent rocky oxide compounds; but they may have united with chlorine, as there must have been—before the chloride of sodium of the ocean was formed — a very large surplus quantity; or being more friable, they were disseminated throughout the rock, or sublimed into the dense atmosphere that then surrounded the hot surface of the Earth.

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*If the base metals were chloridized, they would, being soluble in fresh and salt water, mptly precipitated by many natural reagents, whilst the freed chlorine would unite er suitable metals, and be again precipitated.

These were undoubtedly the simple states of mineralization, when the Earth had cooled down to a low red heat, and the surrounding atmosphere was largely composed of chlorine, the vapor of water, the product of the combustion of hydrogen and oxygen, and carbonic acid gas, similarly produced by oxygen and carbon, during the world's fusion. Thus were oxidized even carbon and hydrogen.

The next universal action that transpired was during the period described in the latter part of Chapter II, Section 1, when all the minerals that were soluble would have been dissolved from off the surface by the condensing steam, and conveyed to the hollows, thus separating the soluble from the insoluble bed-rocks.

Some of the minerals that are now insoluble at ordinary temperatures, in water, would have been quite soluble then (at the high temperature under the extreme pressure described); and others, that resisted the hot waters of the period, would have succumbed to the extremely hot chlorine, or the alkaline solutions that followed, and were held therein until a lower temperature favored their precipitation, or union with other elements, at places where precipitants happened to be situated.

It appears probable that, in this extensive oxidation of the metals, the oxide of sodium formed the greater part of soluble surface scum over the dry Earth, and chlorine gas would be in considerable abundance in the mixed atmosphere, or liquid chlorine under pressure, or hydro-chloric acid, by hot explosive union with hydrogen, that would, in either case, be collected by the falling rain into oceans of chloridated water, in which many of the minerals would be dissolved; some would be precipitated by the soda, as it was washed from the higher grounds, and simultaneously formed the chloride of sodium of the ocean and some of the oxygen of the air.

Thus, the greater part of the primitive surface would have been more or less covered with these many precipitations from th oxides of the metals, whilst the interior, below the reach of thes solvents, would retain the original oxides, as first fused or sublimed. These may have been the ruling powers, because mos abundant; but, as all the agents and reagents of nature that fir released or expelled were present, each acted its part in the general reassociation, more particularly during later and colde periods, after the general reaction of carbonic acid had set in t precipitate from the ocean solutions its chloride of lime into th purely chemical and inorganic carbonate of lime, secondar rock formations, which thus fixed and recorded the first evidenc of the presence of carbon. At about this time, the first magnesian and magnesian lime rocks would also be deposited; then th Azoic calciferous slates and various mixtures, from the disintegration of primitive granite, when mineral oxides would be a the same time more or less disseminated throughout these formations, until the liquid agencies ceased to dissolve and convey t the ocean reservoir any considerable amount of mineral waters.

This manner of distribution would deposit the minerals in diminishing quantities, as time passed away, and the later organically and mechanically formed secondary rocks would consequently contain much less than those that were deposited during the hot Azoic, less tranquil times; and such is precisely the case.

Thus, the minerals must have been *first distributed* throughout the rocks *before the fracturing* of the true fissure veins, or formation of the various receptacles for subsequent aggregations.

HOW MINERALS WERE FORMED IN VEINS, ETC.

It has been clearly shown above that the mineralizing agencies of fire and fluids had not thus far done more than to *oxidize and disperse the material elements*, for *future collection and precipitation* into the suitably small receptacles of veins, pockets, or basins, for man's beneficial treatment: but to attempt to explain *all* of the next succeeding complications by any single rule, will be as presumptuous as impossible.

To lay down any particularly fixed theory, "Plutonic" or "Neptunian," "Sublimation" or "Infiltration," for all developments, is monstrously absurd; for it is not only contrary to the known actions and facts of the past and present, but is a chemical impossibility, as the agencies of fire, gases, and liquids, are ernally composing or decomposing; and whilst Time moves, hemical actions will also continue in operation, and change of ondition be more the rule than the exception.

Fire, however, generally supplies the raw materials, either irectly or indirectly, as just described, and sometimes in part) true fissure veins; as it also aids most remarkably in many istances by warming solutions that dissolve certain minerals, 'hich would be insoluble at lower temperatures; whilst the ases and liquids manipulate to perfect the more complicated *rystalline* forms, found by the miner in all *kinds and ages* of *ock* formations, long after the action of fire had ceased its perations.

In reference to the subsequent re-heating of certain spots, alled metamorphism, which has been deemed necessary for rofitable mineral vein systems, it may be here stated that, whatver its cause may have been, the effects were as great for the roduction of minerals; and in favoring the idea that veins are requently formed by the sinking of plains, it should not be forotten that when such deep fractures occurred, an inconceivable mount of lateral pressure and consequent heat must have been rought to bear at such places, before the necessary side-room ould have been effected for the settlement of the outlying plain, nd simultaneous fracture of the vein.

For consideration of this subject, we may suppose that a ystem of true fissure veins had been formed by secondary ontraction, after a spot of the Earth's surface had been metmorphosed, or re-heated by the second approach of internal ire, after the manner described in Chapter VI, section 1. As here stated, the different, parallel, diagonal, and cross veins, likes, and slides, were not all formed simultaneously; and, conequently, frequent shiftings of portions of the earlier veins on he walls of the later have resulted, which afford many interestng records of past progress, and some very palpable present vidence, that favor more recent concentration by aqueous soluions, and the still later depositions of the minerals from their espective salts.

It has been thus substantially proven, on preliminary general grounds, that, although the metallic oxides or chlorides were first supplied by fire, humid re-agents must have generally completed the mineral formations; and such is strongly corroborated by the following facts, unfolded from the various mineral veins, by the thoughtful miner:

1. If the *veins, pockets, etc.*, were filled by fire with *fused quartz*, they must have been then at *full size*, and *all the contraction* of bed-rock that ever did take place must have also occurred at the *moment of fracture*, which is as absurd as it is untrue.

2. None of the homogeneity or other peculiar appearances of a fused mass has ever been detected in such deposits.

3. If fused, and thus intruded, some overflowings would have protruded, similar to those of lava, and such is never seen.

4. Being lighter and more infusible than any of the other elements from volcanic action, it would, because it required greater heat, have been the first, and not the last, to arrive at the surface.

5. It is too purely *the one unmixed oxide of silicium*, to have been fused at this necessarily high temperature, in the presence of other more fusible elements.

6. The minerals contained therein are too unequally disseminated to have been the results of fusion, or sublimation.

7. Disconnected pockets, and the various minute ramifications in distant outlying stratum, and the miniature veins of pebbles, etc., alluded to in the latter part of Chapter VI could not have been so formed.

8. Vein quartz has a constant specific gravity of 2.8, whilst that from fusion is but about 2.15.

9. Volcanoes never eject pure quartz, or other pure, unmixed elements.

10. Fluor spar (fluate of lime), and heavy spar (sulphate of baryta), with many other volatile compounds, and even water, are often found completely enclosed in quartz, which could not have existed here, any more than in the primitive bed-rocks, if created by fire.

Thus much, and more, may be brought to bear against the general and independent actions of the "Plutonic" and "Sublimation" theories; and, to still further favor those of the "Neptunian" and "Infiltration," the following may be added thereto:

11. We have positive proofs, in the laboratories of Nature and

Art, that not only many of the reactions *can be*, but that they *are being* produced by natural humid causes; whilst fire, both in nature and art, fails to perform similarly perfected results.

12. Constitutionally and mechanically enclosed waters are as perfectly consistent with the aqueous, as unnatural and impossible by fire.

13. Changes of strata generally effect corresponding variations in the quality and quantity of the minerals, as the veins pass through their respective sections, from the presence or absence of solvents or precipitants. These do not apply favorably to fire.

14. Free passage of water favors the presence of the minerals in veins.

15. It frequently happens, in the most complicated systems of mineral veins, where several ages of fractures occur, that when a mineralized vein has been "heaved" or shifted sideways by a cross-vein from its original position, by irregular contraction of the country, it is rich in mineral on the one side of the influential crossing, and poor on the other; thus showing that the minerals were deposited by water, long after fire was in action.

16. True fissure vein quartz invariably shows laminations, or book-like bands, more or less parallel to the walls of the vein, whilst fused quartz does not; which laminations, (being deposited separately on each wall, as the walls receded by contraction, or from my new theory of subsidence,) more centrally crystallized cavities are frequently found, that partake of somewhat similar parallelism.

17. It often occurs that separate courses of tin, copper, and iron, are found in the same vein, for some several feet; then the whole becomes more or less intimately disseminated and speckled with each; or a single course of the one, or the other, may be found as the level is continued, intervening frequent barren sections of the vein; all of which appear as natural to the aqueous as unnatural for the more equally dispersing and regular productions of fire.

18. Their constitutional or equivalent forms, although extremely varied, are always exact: some of which are derived from the surface, and not from beneath, others are even organic and unnatural for the products of fire.

19. The upward, chimney-like speed of the sublimations of

the minerals, from the action of fire, would have effectually prevented the downward access of these necessary elements for the existing combinations in veins, at all depths.

20. They would have been richer for such varieties at the top, and retain only one or two fire compounds at deeper sections.

21. The minerals are often deposited in crystals in the central and last formed quartz cavities, on the *previously perfected quartz crystals.*

22. The walls of veins that, at first fracture, must have *exactly corresponded*, do not retain such shapes now; as in many places the walls, as shown by the irregularity of the width of enclosed quartz, are very unlike, a few feet of distance often exposing expanded concavities, that could not have been formed by other means than actual dissolution of the wall-rocks, probably by hot water hydrating the silicic acid and silicates of potash, that compose such country.

23. Converging or wedge veins intervening the divisions of secondary stratum, which run to a thin point in depth, *must have been* formed by *aqueous solutions*, and not by fusion; unless the minerals were actually poured in from above, which is absurd.

24. The pure carbonates of lime, and baryta; the sulphates of lime and baryta; as well as the fluate of lime matrices of veins, are much more natural to the aqueous than to any igneous creations.

25. Silica or silicic acid must also be in natural solution, for it is found in animals, plants and petrifactions.

26. Perhaps the greatest of all the reasons for favoring the solution theory is, however, that of the vein matter being of pure character, and this I account for by the fact that only *certain vein elements are soluble* in the aqueous surface washings into the vein and in the various percolations of mineral waters from the adjoining country rocks; or *if soluble* these vein ingredients only are then subject to *precipitation* by *natural re-agents.*

27. Mineral waters are quite common, and the ocean is a reservoir of the mineral solutions of gold, silver, copper, iron, lead, etc.

These facts afford sufficient evidence that the chemistry of fire has not ruled supremely in the formation of the minerals, but merely supplied the crude elemental compounds by general sublimations, to the hot and compressed aqueous solutions of the deepest sections of mineral veins.

Internal fire has, however, by creating, under the suitably extreme pressure of the water in veins, *sufficient degrees of heat* to render many substances much more soluble, either alone or assisted by acids or alkalies, that, under ordinary circumstances, are almost insoluble therein; as quartz (silicic acid), fluor spar (fluate of lime), heavy spar (sulphate of baryta), etc., as well as the more regular metallic mineral elements.

Since the time of my being educated in the chemical and mechanical sections of my profession, some forty years since, when I became acquainted with the general laws of sensible and latent heats, more particularly as applied to water and its vapor, I have been strongly impressed with the notions (as expressed in Chapter II, Part 1) that highly heated water had much to do with the formations of matrices and minerals in lodes, as well as the modifications of the earlier secondary surface rocks; and that conviction has been strengthened by close observation during long experience.

To render these principles of action and reaction more intelligible, we will suppose that metamorphic action had preceded the time when the veins were formed, and that the belts of country between the fissures had commenced receding (by contraction, etc.), to expand the width of the intervening spaces, in which the elements that now form veins were deposited. As these walls separated, surface water would force its way down to the hot interior sections of such fissures, which, at only 1,500 feet deep, would create, from its own weight, a pressure of fifty atmospheres, which, if sufficient heat was also present, would raise the boiling point of pure water to 510.6°, and of water that contained chemical salts to a much higher degree; whilst still deeper sections, under greater pressure and consequent temperature, would attain sufficient heat, not only to dissolve, but to even melt away, many of the metals. Thus, the matrices and metals would, at least, have been readily dissolved into solutions with water alone, and as these solutions became more *equalized* from *deep* to *shallow sections* of the veins, the pressure and heat becoming less, they would, *being ruled by such change of condition*, again *deposit from the colder solution* the matrices and minerals accordingly, on the walls of the veins thus being formed.

This solvent would collect the minerals from sublimation as well as by infiltration, and deposit them in the shallower sections, by *cold alone* as well as with the *naturally re-acting elements* then present.

In the general first fusion, and also in partial volcanic fusions, sulphur and chlorine have been volatilized in considerable quantities; and it is therefore probable, perhaps imperative, that those notorious elements have sometimes united to the hot water their superior solvent properties, and thus produced, at a less temperature, more shallow solutions and diversified precipitates, from the various causes of *lessening of temperature*, *dilution of the solution with surface water*, and the *decomposition of the silicates of soda*, or *potash*, from the adjoining rocks.

The lessening of temperature, watering of the solution, and the alkalies, have all been more or less conducive to their deposition, but mostly the latter, which, in the laboratory, speedily precipitates aluminium, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iridium, iron, lead, manganese, mercury, molybdenum, nickel, osmium, palladium, platinum, rhodium, silver, tin, uranium, vanadium, zinc, etc.

Some of these are soluble in excess of these alkalies, whilst others are insoluble, and undergo other more modern changes, until, by some process peculiar to very long-continued natural causes unknown in speedy reactions of artificial chemistry, they unite with the various elements into more permanently well defined, compact crystals, such as arseniurets, sulphurets, etc.

Hot solutions of potash or soda have probably sometimes formed the first deep solution, and deposited in the shallow, less compressed, colder sections, the first simple mineral supplies, which, gradually uniting by natural causes with their different favorite elements, formed the present more stable base mineral compounds.

That one or another of the hot solutions obtained solvency is strongly substantiated by the fact that metamorphism has been most apparent when the minerals are found in such concentrated forms; whilst the invariable disintegration and decomposition of the alkaline rocks of the shallow sections of veins would mostly favor the acidified, highly heated, deep-water solvent, and precipitation by the released potash or soda from shallow sections, with subsequent secondary compositions peculiarly performed by much slower natural causes.

Be it, however, as it may, it has been governed by circumstances, and some of the minerals, such as surface deposits of tin, iron, manganese, lead, silver, gold, platinum, etc., must have been formed in a more simple manner.

As also in districts which overlie volcanic calcinations of mineral oxides, that either remained as such, or compounded with surface carbon, ocean chlorine, or organic elements; as the carbonates of copper, lead, etc.; the chloride of silver, the carbonate, phosphate, and oxalate of iron, etc.; all of which, form either at, or near to, the surface.

Remarkable illustrations of the first, are seen in the dry and shallow sections of all copper veins; where water carries down carbonaceous organic matter, that decomposes and unites with such high formations of copper ores, in a comparatively short time. These carbonates are never seen below the permanent water-level, at first exposure, during the deeper excavations; but sometimes the copper will become thus partially carbonated even in a few weeks after, and stain the backs of the levels with their surpassingly gay colors of blue and green.

The second may be seen in the similar, more massive carbonates of lead, from the aqueous deposition, as well as those sublimations of oxides over actual volcanic heat, which have been changed to carbonates by subsequent dry evulsions or wet infiltrations of carbonic acid.

The third is that of the irregular deposits of chloride of silver, at and near the surface, which are found more or less in all uplifted silver regions previously covered by salt water; extensive modern instances of which have created such excitement at White Pine, Hot Creek, and Reveille, in the State of Nevada. This whole region has been more or less changed from the level of the ocean's bed to the present irregular contour of surface, and little doubt can be entertained that the more general solvent of the silver was boiling sulphuric acid, which collected and brought the sulphate of silver through the various fissures toward the surface, until it reached the pr[illegible]nce of the oceanic solution of salt, and became precipitated as chloride of silver.

The fourth examples are the enormous masses of carbonate of iron that are worked from the layers found in the English coal measures; the numerous highly colored phosphates of iron, variously found at and near the surface, sometimes in the interior of fossils, and in fossiliferous ferro-manganic sands; and the oxalate of iron, which has been formed in presence of, and during the decomposition of succulent plants.

THE FORMATION OF GOLD AT THE SURFACE, AND IN VEINS.

In the careful consideration of this subject, the following pertinent facts, are exceedingly valuable for our purpose, and must not be overlooked:

1. It has been often stated by reliable authorities that gold has *never been found entirely unalloyed with silver*, and that it is *very seldom* free from copper and iron.
2. In a gold-yielding country, the sulphuret of iron, from veins, invariably contains more or less gold; iron is also found alloyed with gold, silver, etc., etc.
3. The sections of rock which contain gold-bearing quartz veins have been much tilted from original positions.
4. All of the profitable gold fields and gold-quartz veins of the world are near the borders of present or past oceans.
5. All of the rich gold-quartz veins are either in the Paleozoic, or very near thereto in the metamorphosed Azoic rocks.
6. All gold-producing regions have been invaded by extensive igneous action, either beneath, upon, or beside the formations.
7. The veins conform more to those of "Segregation" than to "True Fissure," and consequently follow more or less closely the divisions of strata parallel with the mountain chain or line of general upheaval, and consequently they generally underlie towards or beneath the ancient ocean bed.
8. Those lodes which take a somewhat independent fracture, and occasionally traverse the divisions of the stratum obliquely, are richer in gold than others that strictly conform therewith.
9. Placer gold is obtained in such large quantities and is *so differently characterized* that all of it could not have been derived from quartz veins.
10. Platinum is found as [illegible]etal in alluvial gravel, but never in veins or in a mineralized condition.
11. Alluvial oxide of tin is also distinctly different in quality to that found in veins.
12. These three metals are soluble in chlorine, and afterwards become insoluble to other natural solvents; the natural *oxide of tin* being also insoluble to even chlorine. If platinum is not

found in veins, but is formed so as to be extracted from alluvial deposits, why should not gold and tin be sometimes thus formed?

13. Iron oxide prevails in all coal measures, gold fields and veins, and is a good and interesting general indicator of value.

14. Now although quartz *appears* to be the very frequent *matrix of gold*, it may only be a mere receptacle, as other matrices contain it, and even the "bed-rocks" yield platinum, iridium, &c., as well as gold. Specimens of calc spar from the Quervo Mine, Inyo County, California, have, not unfrequently, contained small nuggets of gold.

15. Organic matter precipitates both gold and quartz. See Foot note page 118.

16. It is also highly important to remember that the ocean still contains gold, silver, copper, iron, etc., in solution, that gold fields are on the borders of ancient oceans, and therefore these may have been the principal reservoirs for supplying the minerals and metals to veins and alluvial deposits.

Now, the only, really practical and natural, solvent of gold is chlorine water, which may either have *acted before its neutralization by sodium*, or taking the gold deposits of the Americas, for example, we may suppose that the whole western coasts of the North, Central, and South Americas, were, at a not very remote period of their formation, so warm, from very extensive volcanic action, as to cause portions of the ocean border to *boil*, from the northern to the southern extremes, whilst many regions of the land were sufficiently hot and acidified to free the chlorine from the salt that would have been deposited over the surface or within the fissures of the rock, which, being moistened by water from rains, would have thus dissolved the gold, etc.; or this chlorine solvent may have been sometimes formed by the action of (naturally produced) sulphuric acid on chloride of sodium, in the presence of the oxide of manganese, as these three are generally found in such positions, and the formation might have been then completed precisely as in Plattner's artificial process, by precipitation with sulphate of iron.

This solvent of gold, chlorine, being mixed with salt of oceans, would also, when heated, dissolve silver, copper, and iron, which may account for the *invariable alloy* of gold with these metals, and explain many other facts. It was, however, much too soon for the deposition of such into veins, which, at this stage of refrigeration, could not have been formed, and only applies to placer formations and pockets.

At later periods, after the country rock that adjoined the mountains had partially opened, (by the lever-like action of the opposing outlying plain during subsidence,) into fissures, the chloride of gold may have been supplied thereto, or distributed over the surface of the country, until the gold was precipitated in the veins or hollows at or near the surface, by potash, organic matter, sulphate of iron, or volatilization of its chlorine.

It is probable that at a much later period, after the surface had become comparatively cold, and the fissures were better defined, that the salt water from the ocean penetrated them to great depths, when its chloride of sodium solution becoming intensely heated by the adjoining rocks would not only concentrate the salt, gold, etc., but under the extreme pressure thus created the water would have become heated and partially chloridated; and as the heat increased or approached nearer to the point of separation of its chlorine, that quartz, gold, silver, etc., were dissolved out from the rocks, during long action and then precipitated in the veins. The mode of conveyance to the shallow parts of veins would be as for base metals, where the free gold may have been then precipitated by organic matter or potash, and that enclosed in sulphurets, by sulphate of iron, etc., etc. The chlorides of gold, platinum and all such metals, would, however, be quickly freed from chlorine after evaporation.

The above theories will agree with the sixteen facts enumerated; but I am strongly disposed to favor that integral part which supposes that highly heated water slowly dissolves and hydrates silicic acid, which, if not the complete chemical solvent of all, at least holds and retains the metals in solution, until they arrive at, and are crystallized or precipitated in, the shallow sections of veins, in aggregated ribbons or bands which generally run in parallel laminations to the walls of mineral veins, as they recede from each other.

This peculiar lamellose structure of extensive veins, more particularly those of "True Fissure," have been, I think, produced by sudden intermittent motions of the receding walls; as it is impossible that such extremely slow average rate of travel should be mathematically regular; more particularly during earthquakes, which have occasionally shaken all the districts of the world.

During this expansion of the walls of fissures, it is probable that, with few exceptions, they have had but very little empty space at any time between their accumulating dualistic crystallizations, as the transverse subsidence of outlying plains was, after the rule of the new theory explained, by separate and innumerable motions.

The expansions and contractions of summer and winter, by exerting an influence to only some few feet deep, just so far as the rock is influenced by the Sun during the changing season, may have caused this structure, as the surface rock, by abutting irregularly, forced the partially solidified siliceous waters up and down, by varying the thus regulated thin spaces intervening the deeper walls of the vein, and compressing the quartz into laminations during winter. In hard surface rock districts, this is not merely hypothetical, for, sixteen years since, I had an opportunity of proving the old story to be true, "That the springs of water arose at the winter season of the year, whether rain fell or not," however ridiculous it may appear. In the reworking of an old Cornish mine, we had occasion to fix what is called a "Fend-off" (a sort of "Bell-crank") to the main pumping rod for changing the angle, in a shaft that was partially filled with water up to within a few feet of the work, during an unusually dry autumn and early winter; when, some time after the cold weather had set in, although no rain had fallen, the water commenced to rise in this shaft and throughout the whole length of the mine, and very gradually ran into a level that showed its progress in a very exact manner, as the level had been slightly graded from the horizontal, for better drainage: nothing had been thrown into the workings, and all the other surrounding mines were much deeper, so that this principle of *contracting surface* could alone account for the winter's flowing of the water from the consequent lessening of the size of the vein beneath.

It appears, from those exceedingly interesting and very ancient fossils of the peculiarly siliceous organisms called "Diatoms," recently found to be of vegetable nature, that warm waters must have then held silica in a suitable solution for their growth; and the modern warm siliceous alkaline springs show another substantial fact, that where quartz is in solution, it does not precipitate until it becomes cold, and even then but very slowly. Thus, in the later, cold alkaline solution period, "Diatoms" ceased to grow, and the calcareous "Desmids" prevailed. Soluble silica is yet supplied to animals, plants and petrifactions.

These facts also serve to still further substantiate the "Aqueous" theory for quartz formations, and show most palpably that the quartz and gold of gravel deposits are mostly of distinctly separate formation to that found in veins; and although some may have been broken off and washed from their outcrops, the greater part—more particularly the large nuggets—were disintegrated from the pockets near the surface of the *then* much larger and higher mountains by the force of water, etc.

Gold has continued to be formed, both at the surface and in the veins, up to a very recent period, probably to the present hour; as often instanced in the placers by its being found deposited on wood in various stages of petrifaction, and sometimes in the crystallized "vughs" or cavities of quartz veins, and as recently embossed deposits on the perfectly well defined surfaces of the *previously completed* and *last formed* quartz crystals taken from the central laminations of veins.

It will be necessary, in this connection, to caution the explorer and miner for these precious metals against the too often repeated statements put forward by authors, that the precious metals have not been found in Azoic rocks, as it may lead to serious errors, unless fully understood. It is true that they have not been found, any more than the base minerals, in the real *primitive bottom*, first fused rock, as it originally lies, and as described in Section 1, Chapter I; but, like those minerals, the precious metals have been found in whole systems of veins, that traversed some of the "Broken" and "Disjointed," metamorphosed, crystalline Azoic rocks described in Chapter II, Section 1, and Chapters III and IV, Section 2, where these adjoin the extensively metamorphosed Paleozoic secondary rocks forming the ancient beds of oceans and their present, high and dry, borders.

FORMATION OF PLATINUM, IRIDIUM, OSMIUM, PALLADIUM, RHODIUM, ETC.

Platinum, iridium, and palladium, are soluble in chlorine; but osmium and rhodium, when unalloyed, are at least very slowly soluble under ordinary conditions. These metals all carry strong family resemblance for infusibility, insolubility, malleability, hardness, texture, color, and manner of combination, and are generally found associated as alloys with platinum.

Although oftentimes found in the placers with gold, it is not their invariable associate, as these metals, headed by platinum, take independent positions under the apparently imperative conditions of the presence of greenstone, eruptive rocks, or serpentine. It is also a remarkable fact that chromate of iron has been always found where these metals are most abundant, which must be because the same rock is a matrix for both, unless its presence is required in some way, as the sulphuret of iron (originally sulphate) is for the precipitation of gold. These white metals (the associates of platinum) are of very high specific gravity, iridium ranging from 23 to 26, the *heaviest of all substances;* platinum being always 21.5. They form from two to five oxides, and from two to four chlorides. They are, moreover, so very infusible, that no natural fire can be made sufficiently hot to melt them; the artificially combined influence of the concentrated oxy-hydrogen blowpipe flames being only sufficient for this purpose; so that, remembering all these facts, and that they are the heaviest of all metals, I see no other way that they could have been brought to the surface of our globe, but in a similar manner (for the reasons previously stated) for the other metals; that is, as volatile chlorides. These are notoriously unstable, and nothing would be required but short exposure for release and reduction to metallic states; which, I think, in this instance, was realized in the rock itself, which has been since disintegrated by water, etc., in sufficient quantities for the release and concentration of the small particles of nuggets of these metals that are invariably found near such eruptive rocks.

This opinion appears to be well substantiated from the facts that *these metals are not necessarily associated with quartz*, or *ever lie in quartz veins*, and are *always found in and around* these somewhat peculiar, eruptive rocks. Why should not gold and tin oxide be found in like manner with gravel? These metals, being *naturally infusible*, and so much *heavier than the bed-rocks*, afford conclusive evidence that all the heavy metals must have been brought to the surface by some highly heated volatile associate, which, if not oxygen, may have been chlorine, so abundant before the formation of chloride of sodium.

These gases may have acted in an infinitely slow manner, on most minute particles or atoms, during the elevation of such metals to the surface, as they are of rare occurrence, and their total quantities extremely small.

CHAPTER VIII.

THE PECULIAR CHARACTERISTICS OF "TRUE FISSURE VEINS," AND THEIR CONSTITUENT COMBINATIONS, POSITIONS, DIRECTIONS, AND DIPS—GENERAL COMPORTMENT WHEN TRAVERSING DIFFERENT STRATA, WHEN FORMING INTERSECTIONS AND JUNCTIONS WITH EACH OTHER, OR WITH CROSS-COURSES, DIKES, AND SLIDES—INFLUENCE OF CROSS-COURSES, SLIDES, AND DIKES—SUMMARY OF THE EFFECTS PRODUCED BY THESE COLLECTIVE CAUSES.

"True fissure veins" are always found in metamorphosed (reheated spots of strata), chiefly in the "Azoic," less frequently in the "Paleozoic," and no good mine has been found in England above the "Triassic," or First Period of the "Mesozoic" or Third Time; but, in some other parts of the world, antimony, lead, iron, manganese, and mercury, in the Second and Third Periods of this "Mesozoic" Time, when sufficiently metamorphosed in veins, which are, however, not well defined True Fissures, but modifications from extensive volcanic upheaval, and consequent sublimations.

1. "True fissure veins" are rarely found unaccompanied by others, and various systems or ages of their fractures can often be observed, as they have slidden at different times upon each other.

2. They do not conform to the cleavage of the stratum, or lie in the intervening division between two distinctly different strata.

3. They do not generally decrease, but rather increase their width and riches, at the greatest depths attained by man, although apparently occasional instances occur of the reverse.

4. Their encasing walls are remarkable for regular definition, smoothness, and unctuous or soap-like, clay surfaces.

5. Their constituents of matrices and minerals are always found in laminations more or less conforming to general parallel-

m with the encasing walls; and, when short diagonal "splices" r "vughs" occur, they are almost invariably in similar planes.

6. The minerals are sometimes found in most distinct indiidual courses, the one beside the other, or in different parts of he vein's width; at other times, speckled indiscriminately hroughout, or in occasional stones of each; whilst, more freuently, they are so intimately mixed that they cannot be seprated by hand.

7. Thus, the minerals are associated side by side with entirely lifferent and numerous elements: the permanently insoluble xide of tin beside the sulphurets of iron, copper, zinc, and ometimes lead; or arseniurets, oxides, carbonates, etc , of the ne or the other, some in massive and others in crystalline forms; ll of which, I presume, are derived from chlorides or oxides, the xide of tin alone retaining that insoluble form, whilst the others ave passed, or are still passing, into other combinations.

POSITIONS, DIRECTIONS, DIPS, AND GENERAL COMPORTMENT WHEN TRAVERSING DIFFERENT STRATA, OTHER VEINS, OR CROSS-COURSES, DIKES, AND SLIDES.

8. "True fissure" veins take independent paths through all of the metamorphosed strata lying in their course or dip. If, however, a stratum of rock overlies those that had been metamorphosed before, the vein *does not* pass out beyond the earlier heated spot, into that since deposited thereon.

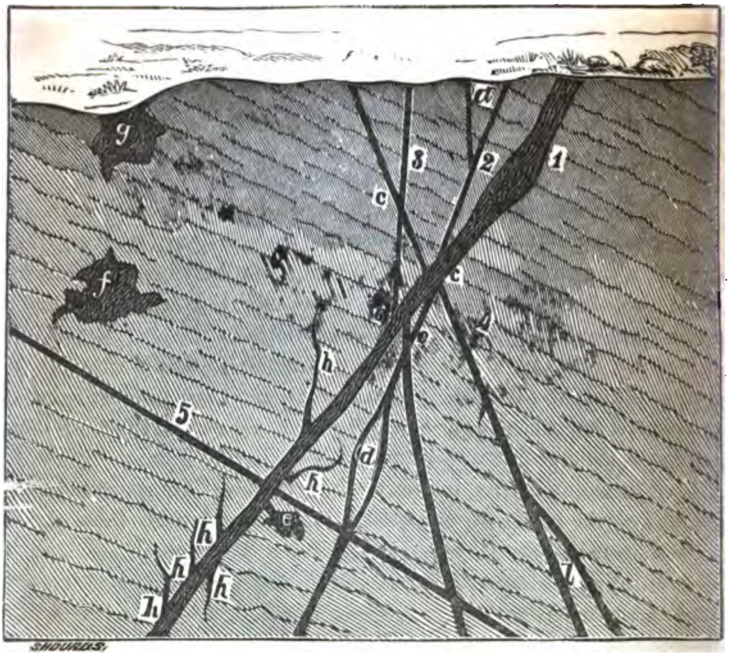
9. They partake somewhat of parallelism, for each age of fracture, but take all bearings and dips at their different ages, as governed by the directions of the lines of contraction or subsidence of the age.

10. The veins of the *one parallel*, in the *same* complicated system, will all be richer in minerals of similar kinds, than those that run transversely thereto; not, I think, from any *difference* of *magnetic* influence caused by bearing, but from *age of fracture* alone, and consequently larger space and longer action for better solution and precipitation of the minerals.

11. The magnetic bearings of veins have been greatly influenced by the general contours and directions of the adjoining ridges of the more primitive granitic rocks, and vary their degrees of bearing and dip accordingly, and the richer veins generally parallel such influential causes for conformity.

12. However near the systems of veins or districts may lie to each other, certain peculiarly local influences will apply, as particularly displayed in Cornwall, where, commencing at the St. Just District, near the Land's End of England, the north and south veins have been most productive for copper and tin; at Marazion, those bearing northwest and southeast have been most profitable; whilst, in the centre of the county (only about thirty miles inclusive), at Camborne, Redruth, Gwennap, and St. Agnes Districts, those bearing east and west are alone mineralized. North and south bearing mountains prevail throughout the world, and they as often govern the direction of veins, but profitable veins are found on the slopes and foot-hills of mountains at all angles of the theodolite.

Fig. 4.



13. It may be observed that "True fissure" veins seldom dip less than 45° from the horizon, are frequently near to, and sometimes quite vertical; each vein takes independent direction and dip, often passing forward and downward through the others, at all les within these limits; one may, for instance (as in Fig. 4),

dip northerly at 50°, whilst another overlying this may also dip northerly at 60°, and pass down through it; a third may still overlie and dip northerly at 85°, which also, after passing through both, may change its dip from north to south; a fourth dips south through all these at 70°, or any other degree; whilst a fifth may be a "slide," which will also occasionally disorder or shift the lode; the whole being also of somewhat different degrees of direction, and traversed by cross-courses that partake of similar, but transverse differences of the angles of bearing and dip. On this figure, *a* shows a Y intersection; *b*, an inverted Y intersection; *c*, *c*, *c*, X intersections; *d*, a "horse" in the vein; *e*, a "carbona;" *f*, a "bonanza," or pocket; *g*, a surface deposit; and *h*, *h*, *h*, *h*, *h*, *h*, "feeders."[*]

14. Some parts of "true fissure" veins, and almost invariably where the dip is more vertical, contain more mineral than others.

15. Certain directions, and corresponding parallelisms, of "true fissure" veins of a district, will always contain more mineral than other directions.

The two last are general rules, which must have been noticed by every thoughtful practical miner; and although the reasons have not yet been made apparent, some tangible causes must have created such invariably marked results. As it is very important that this should be fully understood by the miner, and more particularly by those entering new districts, I will endeavor, by the aid of two illustrations, to explain both the nature of, and reasons for, this occurrence.

First, let Fig. 5 represent a vertical section of a fissure that had thus changed its dip from that of A to B; and again from C to that of D. A and C are the profitable portions of the vein, simply because B and D are *more contracted*, and *prevented an equally free passage of the mineral waters*. The arrows represent the *horizontal line of contraction*, that opened the rocks from

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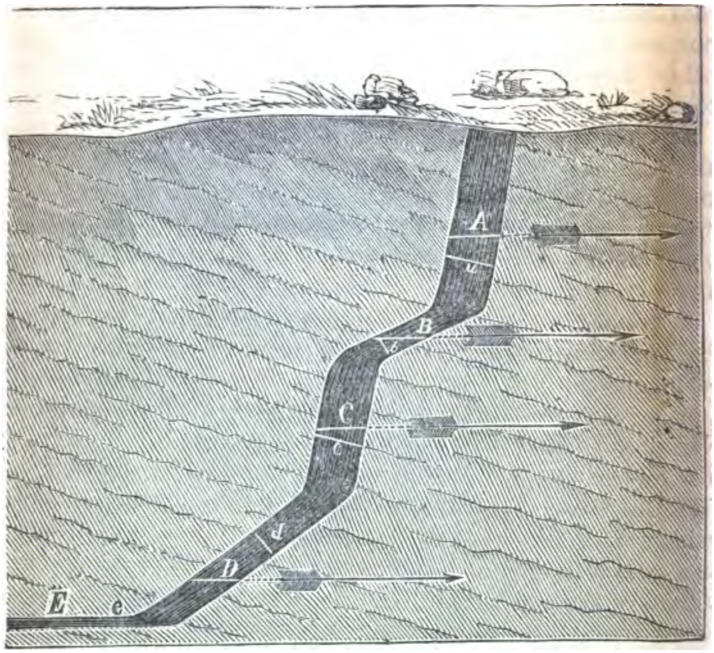
[*] A lode or vein, *to be recognized as such by miners*, whether it be "True fissure lode," traversing through all rocks; or "Wedge lode," occupying the spaces between upturned layers of natural stratum; or "Intervening lode," within the terminal planes of two entirely different opposing strata; must contain at least one of the matrices, quartz, fluor spar, calc spar, or heavy spar in addition to its metals and metallic ores. *Therefore, any formation* which is chiefly composed of "*Country rock*" instead of the above *matrices*, although lying between equally smooth, well defined walls, and yielding minerals from *irregular seams* and pockets, cannot be deemed a *lode or vein in a correct mining sense*. It is either a mineralized *igneous dike, or reef of tilted stratum*.

original contact for the *after infiltration* of the matrices and minerals. Now, as the horizontal lines marked by the arrows show the *direction* of the separation of the walls of the vein by contraction, so will the corresponding parallel lines at A and B, C and D, measure the *amount* of this contraction through *similar lines* in the vein; whereas, the width of the vein must be measured, in each case, at A and B, as well as at C and D, by *right-angled* lines, to the *separate* and *different dips* of the vein at A and B, C and D.

Fig. 5.



If any one should fail to understand this argument, from the sketch, let him trace off, on transparent paper, the *single* line that shows the left-hand wall of this vein, and move it in a vertical position with the bottom edge of paper resting on the table, in the line of contraction marked by the parallel arrows, a distance to the right that equals any one of the parallel measurements of travel marked A, B, C or D, and he will find (because these are all equal and parallel to each other) that this left-hand wall, when thus correctly moved, will correspond to the right-hand wall of the vein, which, of course, when first fractured, also corresponded. Or, trace this line with a pencil or needle's point on a piece of card paper, placed beneath, and cut through this line that marks the left-hand wall, with scissors, and he will have an exact representation of the country, or bed-rock, on both sides of the vein, which, of course, touched when cut, as well as when fractured; so that, by holding the one left wall paper in the left hand, and the other right wall paper in the right hand, he may thoroughly satisfy himself in every way regarding these movements, and that, immediately motion is given from actual contact, a consequent difference of width ensues, and that no other direction for travel will produce the same right-angled widths for corresponding dips of the vein.

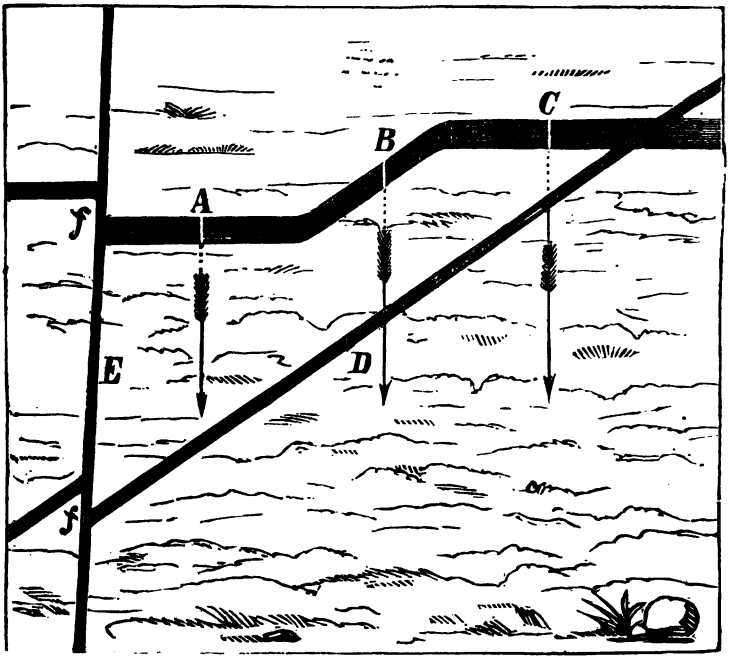
It therefore becomes apparent that where the dip was greater, the vein was also larger, and at E, where it is supposed to be horizontal, it is of no width whatever; and, consequently, more freedom for the conveyance of mineral waters and subsequent precipitation of minerals, prevailed in such expanded sections, than where the vein was more contracted.

It is not unusual in countries which have been much disturbed by earthquakes that the *wall and bed-rock*, of the *one side*, has slidden *downward by the other*, and in such cases the effects will appear, either to agree with those described or be quite the reverse, and for the following reason, which you can and should, demonstrate for yourself by the card suggested; because it is, like the preceding, really very instructive and valuable for the miner; as after once knowing the direction and part moved, he can work with much greater certainty amidst these changing positions of the adjoining country, and consequent size and quality of his vein.

Thus you will confirm my views, as shown by the lode of changing underlie or dip in the illustration, by first simply moving one or both away from each other, to show that the parts of *least dip* will be of *less* size; then by slowly lowering the right hand portion of the card, you may produce, by such slide, a *similar effect;* and lastly by lowering the left hand part, expose the *very opposite result.*

When the downward motion occurs, the vein shows, generally well marked corrugated faces, either on the walls, or within its laminations, of quartz; the former, when seen on *both walls*, was probably effected before the opening of the vein, and the latter position marks the exact stage of filling at the time. The direction is frequently at a fast dipping angle and well marked, but seldom vertical, and serves to guide towards effects of sizes and dips of mineral deposits produced.

Fig. 6.



Such motions are sometimes treacherous in results, as they are liable to bottom, rock on rock, at the place of less angled dip, where the vein may cease, and make an *apparent* fool of the *most experienced* miner.

Referring also to some portions of veins, having certain surface bearings richer than others, (and which sometimes may apply, for similar reasons, to "caunting" and "cross veins"), it will be only necessary, instead of looking at the *vertical section's* line of contraction as *regards dip*, to take a "*bird's-eye*" view of the *sur-*

face or *ground plan* of the veins, as shown by Figure 6, and, regardless of the last section, to ascertain the *bearing by magnetic needle* of the *line of contraction* that caused the withdrawal of the walls so as to produce the actual widths exposed.

Let Figure 6 represent the ground plan of three veins, a regular vein, a caunter (or diagonal vein), and a cross-course; the bearing of the line of contraction, according to the previous argument would be at or about a right-angle from the average direction and the widest part or parts of the principal vein, as shown by the arrows, which however can be more promptly and exactly demonstrated by the lateral motions of the bisected card, which would also inform you if the both motions had combined to produce the effect, of your individual example.

It appears as plain on this plan as it did by the section, that these geometrical, or merely mechanical explanations, show sufficient reasons for larger spaces at A and C than at B, and consequently more capacity for receiving minerals; and that no greater difference in the principle of action exists, between the vertical and the horizontal, than that the line of sectional contraction of Figure 5 is a constantly close approximate to that of the Earth's surface, or a tangent to the Earth's radius, whilst that of the plan, Figure 6, is as frequently changeable as the direction of the veins, of each individual district throughout the world.

This is a novel and tangible cause for the well-observed fact of such richer portions of veins, and I think that it may be also the reason why veins of small dip, "caunters," and "cross-courses" are less mineralized than those that lie more transversely to the lines of greater contraction.

Where an occasional exception occurs to this rule, the subsequent decompositions have, for similar reasons, again dispersed the minerals.

16. Free passage and much water are regarded as good indications for extensive deposits of the minerals; which also favor these ideas, and that such portions were, and are being, mineralized by infiltration.

17. Lodes often vary in size from other causes than those of direction and dip, as the one wall *actually sliding down* the other, &c.; and the larger places are generally much richer (for the reason of such free passage of water) than other more compact sections.

These frequent expansions or "wallows" of lodes, between irregular walls, that must have been first parallel, may have been also sometimes produced by highly heated water (as described in Chapters II and VII), which would dissolve or hydrate the silicic acid of the silicates of potash and alumina from the adjoining rocks, and thus add to the general solution more of the solvent or matrix, silicic acid, with the alumina or clay, for the joints and walls; whilst the precipitant of potash would also be similarly watered and released from its affinity by this high degree of heat, and provide a natural re-agent for the precipitation of minerals at shallower sections of veins, after the pressure and temperature had become suitable for this change of action.

Organic matter from the surface may have greatly aided these separations and precipitations in the *novel manner* suggested by the foot note at the end of Chapter X, on mineralized zones or reefs of stratum.

18. Lodes (having also the other necessary conditions) which *vary in direction, dip, size,* &c., are more *plentifully supplied* with minerals than those of perfect regularity.

19. When mineralized lodes are intersected or crossed in length or depth by "caunters," "cross-courses," "slides," or "dikes," they are generally improved at and near their junctions; although sometimes the reverse is the case.

20. A lode is sometimes mineralized on the *one* side of such intersections, and not mineralized on the *other* side.

21. A lode is often larger on one side of a cross-course than it is on the other side.

22. A lode is seldom shifted downward in the manner and direction as illustrated by Figure 4, at *c, c,* and *c;* and as rarely horizontally, as shown by Figure 6, at *f* and *f;* but it is more frequently found on the obtuse-angled side, and when not thus situated, if the stratum were transparent, it would be seen that a very small intervening block of country had been shifted to accommodate the more regular motions of the much more extensive controlling sections.

23. The *length of any one lode* is *generally*, and the *total length of all the lodes* of a system of veins that have been thus shifted, is *invariably less* than the present length of the ground in which they now lie; because (as generally supposed) the strata have

idden, or contracted and shortened, more in the one direction an the other.

24. Other guides to the positions of slidden lodes are the mparative percolations and mineralizations (ascertained practilly by taste or analysis) of the waters from both ways, and a ight turning of the vein towards its disjuncted part.

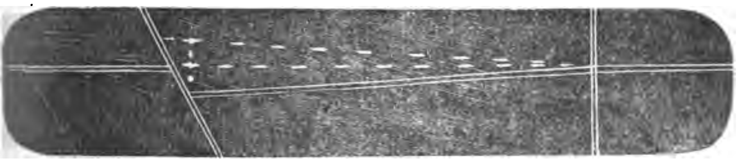
25. True fissure veins seldom crop out boldly *above* the surce of the ground. This, is a general rule, in Cornwall.

26. Much clay beside the walls and the quartz of the vein, a good sign for mineral; probably because it was decomposed rom a congenial feldspathic bed-rock. and also marks a proporionately long time for production, with great age of veins.

27. Rich lodes have their completely barren spots, and the oorest lodes have occasional stones of rich ores, which should ot infatuate and deceive.

28. Lodes of regular yield are the desideratum of the miner. hey are easily worked, and are more reliable. I am of the pinion that although the various strata of coal and bed-rock ave actually changed their places, in a *vertical* manner since eposition, the fissure veins have not been moved *horizontally* to nything like the extent accredited, but were frequently *formed by fracture*, as explained by the accompanying Figure 7.

Fig. 7.



The cross-courses were first formed; then the regular veins, which would naturally sway the *line of breakage* toward the obtuse angle, because the *lesser* distance would give *less resistance*. This is frequently illustrated on the plastered ceilings of rooms. The first cracks run in a regular uninterrupted manner, and the second but interjoin between the others, as illustrated.

THE EFFECTS PRODUCED BY THESE COLLECTIVE CAUSES

Should be carefully and continually observed, as they will serve to guide you, to an eminent degree, in the prospection of the mine. Passing by the minor facts, the subjects of intersections as governed by bearings and dips, disjunctures and heaves, cannot be too well studied, for the correct positions of shafts, levels, &c., as well as for machinery; seeing how many really good mines have been, and are now being, ruined by such ill-considered practices.

These three sectional veins and the following diagram showing the proper and improper modes of working veins, at points of intersections, may be considered out of proper place in this First Volume, as they belong to the subjects of the Second Volume, but as such errors are too common, and I cannot explain the surface and deeper intersections of veins, and enforce the extent of the error, anything like as well, without such actual illustrations, they have been used here, in preference.

It will suffice to caution the explorer and miner against this one great and frequent mistake, by the following three-fold illustration and example, which will apply also to deposits of ore that almost invariably dip more or less, the one or the other way.

Fig. 8, represents a bird's-eye view or plan of a piece of hard and expensive ground, which is 2,000 feet long; herein lies a regular east and west lode, that dips south at 80°; this vein is intersected by an oblique-angled mineralizing "caunter" vein, at the one end, that also dips southerly at 60°; in the middle of the ground, a deposit of mineral is shown, on the east and west lode, dipping east at about 70°; and, at the west end, a mineralizing cross-course dips west at 60°. Thus lie three valuable deposits of mineral; the one in the middle, and the others at each end, following the influences of the "caunter" and "cross-course," and each "shoot," ("chute," "shute," or angular dip of deposit) is about say two hundred feet in length, as shown by the darkened central portion, and those adjoining the intersections.

Now, it may be very easily perceived, that this mine would have been unprofitable if worked as there described and shown, by the positions of the one shaft and several very long levels: for the shaft is too far west for even the central bunch, which gets worse at deeper levels; it is too far off from the fast departing mineral that adjoins the under side of the cross-course, and still worse placed for the eastern intersection of the caunter, which, from being so oblique and dipping so much less than the main lode, carries the mineral, deposited under the intersection,

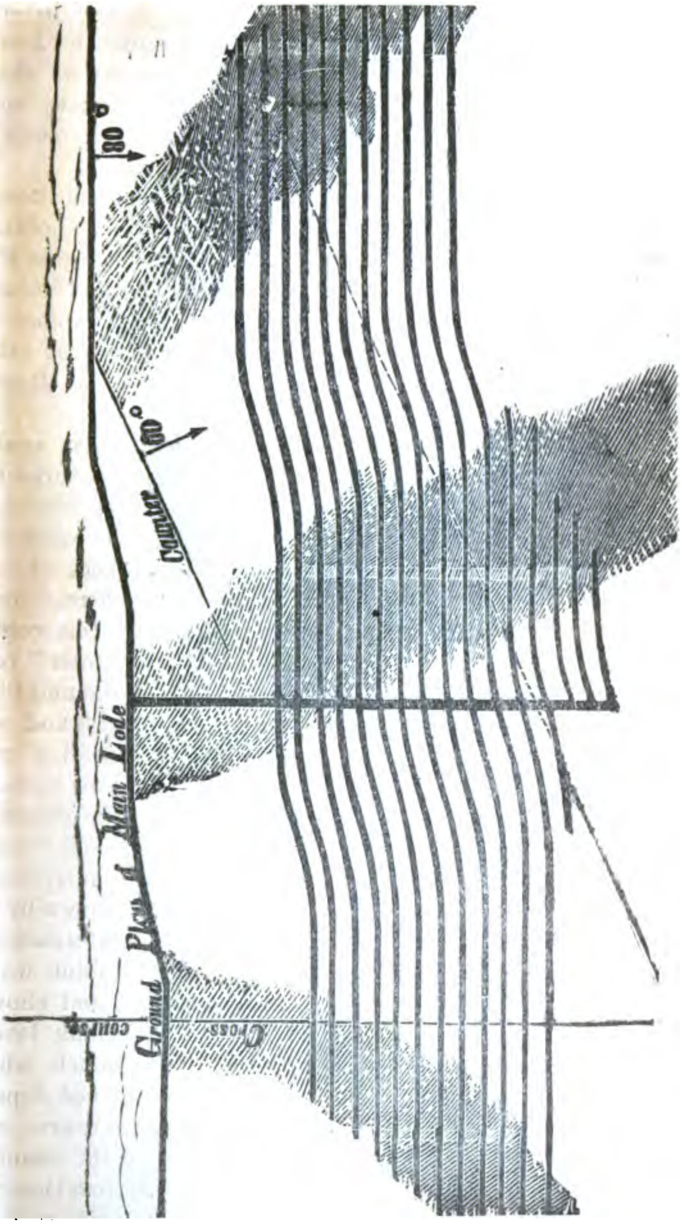
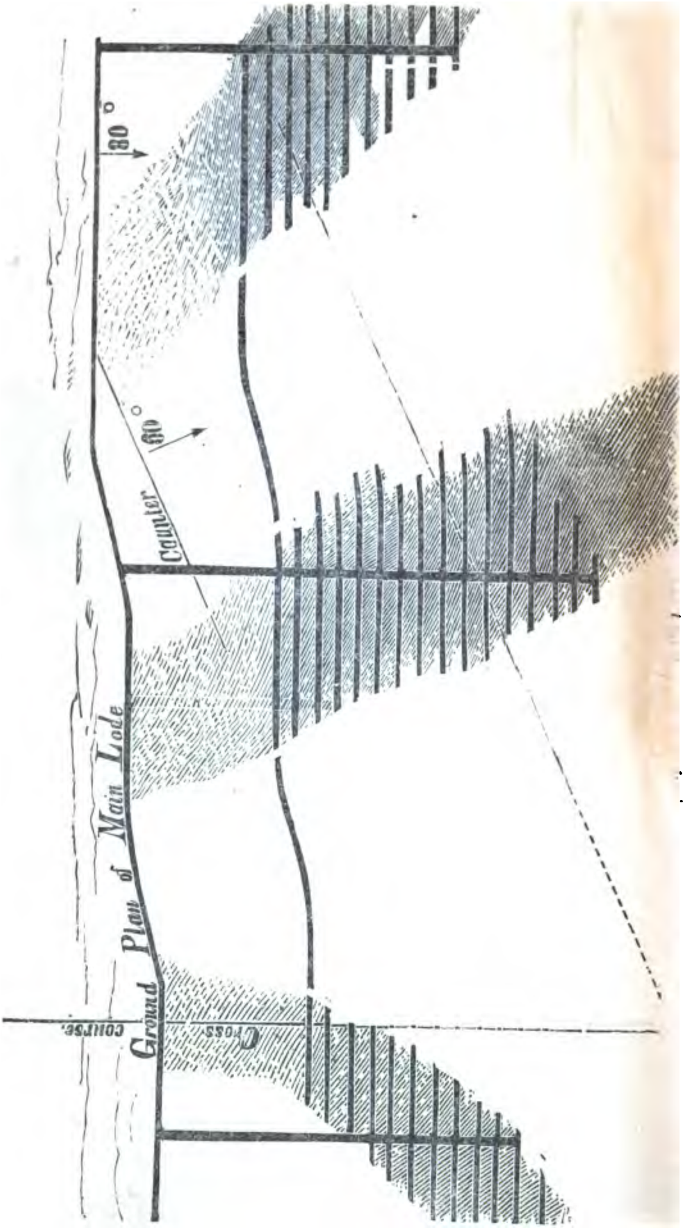


Fig. 8.

Fig. 9.



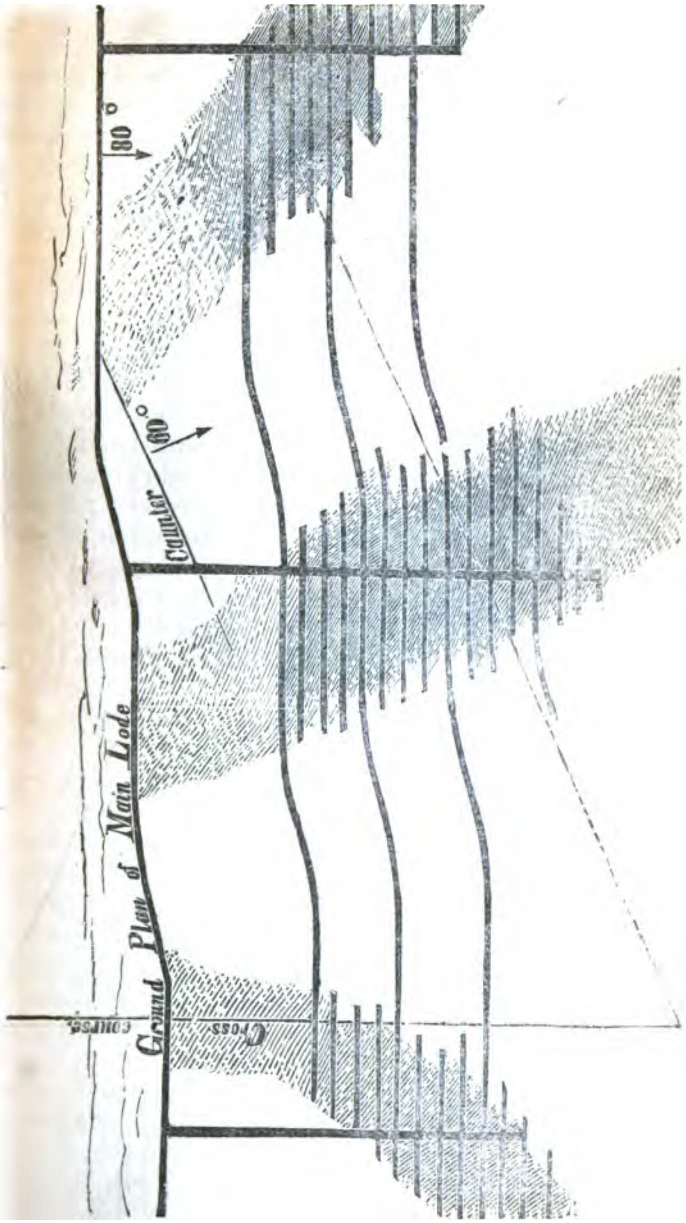


Fig. 10.

rapidly eastward; entirely out of reach of this one shaft, if not into your neighbor's ground.

If such deposits are worthy of being worked, they may be wrought properly, and therefore shafts should be sunk on each, with separate mechanisms, where shown by Fig. 9, to command each deposit, at about midway between the depth where it first commenced to be profitable and the deepest yielding depth of the district; so that the shortest possible length of levels would have to be driven through unmineralized lode.

Two or three *distant*, exploring ventilation and drainage levels, could have been driven from the central pumping power, if deemed more advisable, at distant depths, as shown by Fig. 10.

This will often apply to one "shoot" or strike of deposit, and seldom in the manner illustrated, when it will be more advisable to have two shafts for this deposit—the one for hoisting, the other for pumping—situated from two hundred to four hundred feet asunder, embracing a similar section of the run of ore ground, and also providing, by this simple operation, much better ventilation.

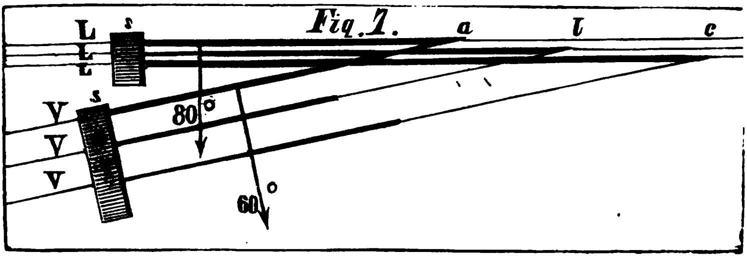
The engine-shaft will be more independently effective for pumping of water; whilst each will help the other in hoisting, ventilation, and traffic; thus, aided by these and double position, the mine will be more expeditiously developed in many ways, but particularly by having four or six sets of levels, instead of only two, continually opening profitable ground.

As it is most important that the rates of advance of such intersections should be, for many reasons, well understood, the following will show an easy method of finding it by construction:

Thus, in Fig. 11, where the first levels from the shafts are communicated, let L, L, and L, be the regular lode, and V, V, and V, the intersecting vein at three different levels, caunting at the angle shown; S is an engine-shaft on L, and S is a shaft on V. The distances between L and L and L are each such as this main lode would gain south, in say one hundred feet deep; now, by marking off the corresponding distances that V, V, V, would gain southerly at similar depths—in this case about thrice as much—and drawing the lines according to the bearing of each vein, we thus arrive at the different points of intersection, *a*, *b*, and *c*, and perceive that its dip is traversing eastwardly, in a dangerously fast and most inconvenient manner, from us.

A good and useful practical model may be made, at a suitable scale, of the veins of a mine as they lie *in situ*, by making an open top box of the size and shape of your surface ground or grant, and as deep as man ever works; in which differently colored wires may be passed through the ends and sides, so as to exactly agree with the several lodes' relative positions, bearings and dips, so that their intersections may be seen by a glance at the different intended levels of the future.*

Fig. 11.



The best, most accurate, and reliable, for *past* workings, are, however, good plans and sections, which should be always kept closely posted, in all respects, and hung on the walls of the office, that all concerned may see them as often as desirable.

The value of the lode at each fathom driven or sunk through, should be invariably recorded on such sections, for future reference, when setting "tribute pitches" or contracts. A duplicate section may be used for this most important purpose.

A very illustrative example of such a section will be given on a future page.

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* This mode of construction will be of great value for tracing the positions of veins at the surface, as they will vary their apparent or concealed courses, according to dips and surface contour, as caused by difference of elevation.

CHAPTER IX.

THE MORE GENERALLY RECOGNIZED PREMONITORY INDICATIONS, FROM THE SHALLOW PORTIONS OF VEINS, FOR PROBABLE INCREASE OF MINERAL WITHIN THE DEEPER SECTIONS.

The most prevalent and congenial matrices of the veins are quartz, fluor spar, and calc spar; which control, to a certain extent, the qualities, quantities and kinds of the minerals.

1. Quartz (silicic acid) is an almost universal matrix for all.

2. Fluor spar (fluate of lime) is not unfavorable for lead and copper.

3. Calc spar (pure, crystallized carbonate of lime) is often favorable for shallow depositions of silver, and sometimes lead, in certain magnesian limestone districts.

Heavy spar (sulphate of baryta) is also found associated with quartz, fluor spar, and calc spar, in moderate quantities; it appears to take its position, however, like carbonate of baryta, more as a chance mineral than significant matrix.

Gypsum (sulphate of lime) also occupies an occasional place in veins and pockets, with the leading matrices which carry the minerals of silver and lead; but appears to have exerted little influence in their mineralization. Dikes of gypsum, which are notoriously deficient of mineral, are more frequent.

4. These matrices being present in a vein, some other indications may be named, amongst which a properly defined vein lies most important; for really valuable deposits must be extensively maintained throughout, as well as contained therein.

A well defined vein conforms to the descriptions given of such in the first part of Chapter VIII, which need not be repeated here.

5. It should not be too small to contain a sufficiency of the particular mineral or metal sought; or so large as to unduly

scatter the mineral throughout the matrices of the vein; the most approved width is about four feet, and when this is much exceeded (for the above reason and the extra expense of securing the ground), the practical value is seldom enhanced.

6. The matrix, whether quartz, fluor or calc spars, single or mixed, must expose that *peculiarly congenial appearance* so familiar to the miner's eye, yet difficult to be described, which should, however, be closely studied by the novice, in the well known rich lodes, as well as in districts equally notorious for their poverty; that he may also recognize the *uncongenial, non-bearing* spars. The best characteristics for prosperity are the following: They should not be too compact, but somewhat friable, "rotten ripe," or "sugar like;" although giving occasional signs of crystallization, they must not be too much crystallized; the quartz should not have a gem-like transparency, but be, in natural condition, and stained by the oxide of iron or manganese, to cream, rust, or rose colors; it should expose, on fracture, a *moist and full, generous appearance,* rather than "dry and hungry;" a repletion of congenial quality, not depletion.

7. It should be of the specific gravity of 2.8, and not of 2.3.

8. The oxide of aluminium (alumina, fluccan, or clay) is invariably present in abundantly mineralized veins, forming two, much to be desired, clay-plastered walls, as well as permeating throughout the mineralized crevices of the vein. This is, of course, an oxidized metal, and as much a mineral as any other; but it appears to have been deposited without the quartz, and not within, as was the case with the other minerals, and probably a subsequent formation, thus far favoring the theory fully described in Chapter VI, where potassa was supposed to have precipitated the minerals from their acid solutions. The alumina (fluccan or clay), *being present in abundance,* is therefore a good indication, because it must have been *derived* from the *adjoining feldspar* during the decomposition of this double *silicate of potassa and alumina;* which must also *have released* its more soluble constitutional *potash* as a *general precipitant,* whilst the alumina followed more slowly in mechanical suspension, to fill the remaining internal seams and outside planes or walls.

9. Chlorite, a mineral that varies in color from olive to bright green; and talc, which is from green to gray—both partaking of the same unctuous surface as clay—are also recognized as being

most reliable indications for gold, as the talcose clay-slates; and for cinnabar, in the chlorite-stained steatitic rocks.

10. The oxide of iron appears to have its point as an indicator, as in the "gossan" of Cornwall, which is believed to be an infallible mark on the *back of a lode* for copper and lead at deeper levels.

11. Sulphuret of iron, too, when in considerable quantity, has a similar, but *deeper* intimation, that copper will be found still deeper. As a rule, the oxide is mixed with an extensively disintegrated quartz, being the result of the decomposition of the sulphurets, which preceded the oxide, and thus released the quartz into friable condition, to a depth of from a few feet to that of, in rare cases, some two hundred feet. The sulphuret next follows underneath in like manner until a change appears, and the copper sulphurets are attained.

The reason that *iron is such a general indicator* in mineral veins is, I think, more owing to its *prevalence in the adjoining bed-rocks,* than to any chemical effect; and like alumina, chlorite, and talc, it shows by its presence that sufficient actions had been at work for solvency, and *ample space* remained for the free traverse of *iron*, and therefore the *other mineral solutions.* It, in other words, evidences continuous water channels in the vein and inclosing country, and by its presence, the probability of all the other accompanying minerals which chanced around.

12. Good indications, for increase of copper and lead in depth, are when an occasional speck or stone of either, or the colors of the blue and green carbonate of the former, or the yellow carbonate of the latter, is seen above the water-line. So, also, for all minerals, the other conditions being present, as to proper definition of the vein, etc., their various ores being found in small quantities in the shallow portions, favor an increase in depth. Tin lodes require the presence of oxide of iron, and a blue stone called "capel," which is composed of quartz, schorl, and hornblende.

In regions of igneous elevations of country, this rule seldom applies, because the minerals are formed by different means, and therefore generally expose the equally good parts of vein or deposit, at or near the surface; so, that, although the *spirit of speculation* in sinking shafts for such similar increase *may be admired*, the *practice* must *be deprecated.*

13. Variations in the sizes and directions of veins are favorable to their mineral yields, whether the change is caused by difference of direction in length or depth, by the sliding of one wall upon the other, or from decomposition and disintegration of the enclosing walls, for reasons previously explained. An occasional "horse" is also more favorable than otherwise. In fact, very straight and regular veins seldom realize profitable returns.

14. Mineral water indicates proximity to its source and consequent approach to large deposits of minerals, both when they are in actual course of deposition from such solutions, and when they are being decomposed into after solutions. Large deposits of minerals, however, have been frequently found intervening the stages of formation and decomposition that afforded no such evidence.

15. Hot water from an advancing level or shaft is often the precursor of mineral deposits, because the water, by percolating through their sulphurets, is warmed to a higher degree than would otherwise result at similar depth.

16. Embossed or "boldly cropping" veins are generally favored, but only because they expose evidence of continuation, rather than plenitude of mineral.

17. In "true fissure" veins, it is a most unusual thing to find much outcrop; and, when present, it is not a good sign for mineral wealth.

The vein should be so friable as to *give way to*, rather than *resist*, the effects produced by washing, freezing, and consequent disintegrations from water, which, aided by chemical decomposition, should produce "gossan."

It must not, however, be forgotten that each district has, to a certain extent, peculiar indications, beyond those already named, and that some of these are occasionally of no very material value.

CHAPTER X.

MINERALIZED REEFS OR ZONES OF STRATUM.

Many profitable mines have been found, in mineral-bearing reefs of tilted strata, where no veins of the ordinary characteristic features and forms existed; although the nature and kind of the rock itself, and general requisites of the surrounding country, were the same in all the necessary conditions, as would have been required for minerals deposited within the walls of regularly well defined veins.

The best known instances of such mineral-yielding formations are those of the cinnabar mines throughout the world, which are generally found, in belts and patches of rock, of a more or less steatitic, or talcose, nature; which may range from compact talc (steatite) to talcose clay-slate, shale or schist, and, in rare instances, to even sandstone. For extensive deposits of this mineral, it is also necessary that sufficient heat had been, at some time in action, for the sublimation of the mercury from beneath; so that it might condense in the more or less extensive ramifications of the internal crevices and irregular pockets of such suitable stratum, and if sulphur was supplied at the same time, cinnabar would have been the final result from their chemical combination. For such reason, igneous action must have prevailed beneath, at some comparatively recent time, and corresponding metamorphism should be expected and sought for at the surface.

The more general indications for cinnabar in the several mines of California which I have examined, are belts of much-distorted and crumbled steatitic strata, the broken surfaces of which have been plentifully stained green by a profusion of chlorite, whilst the cinnabar is sometimes coated with brown or black faces, somewhat similar to mineral pitch.

It has been supposed that a prevalent, coarse red jasper, is also a good sign; but it should be regarded as being more accidental than indicative.

The metal which subsequently united with sulphur to form cinnabar had been evidently volatilized by near protrusion of subterranean heat, and again arrested by condensation during its upward passage through the many seams and pockets, intervening such very irregularly disrupted and cavernous country rocks. The similarly volatile sulphur should be also present to form the subsequent compound sulphuret of mercury, or cinnabar; and some of these mines still expose free sulphur upon the faces of freshly-broken stones, and native mercury or quicksilver within the joints and cavities of the stratum. In several instances, warm surface springs are still running from lower positions not far distant, and some of them actually appear to supply mercury as well as sulphur, which, even at the present time, form cinnabar within the range of their influence.

The celebrated "Steamboat Springs" of Nevada, and the California mine commonly known as the "Sulphur Bank," are noteworthy instances of this kind of deposition; as the former is in actual flow and producing present proof of this mineral's formation and aggregation, and the latter, showing evidences of similar past action, has been, and will probably continue to be, a very profitable source for cinnabar, &c.*

This deposit affords not only illustrative corroboration of such being sometimes profitable, but is peculiarly interesting in many of its geological features. This so-called "Sulphur Bank," situated in Lake county, California, is being very extensively and profitably worked by the "Sulphur Bank Quicksilver Mining Company," and it has been so practically exposed by many large open cuts, that however unusual the formation for such a mineral, its great extent and value cannot be questioned, and it must be recognized as a most important medium and receptacle of mercury.

The site of this extraordinary deposit is some three or four hundred feet south of the eastern limb of the triple-wing shaped

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* There are very many warm springs in these several Western States of the United States of America, which are depositing the matrices of silica, lime, magnesia, &c., with small buantities of the ordinary commercial minerals.

Clear Lake, upon the gentle southern declivity of an elongated hillock, having a maximum height of not more than one hundred feet above the water of the lake, which is about fifteen hundred feet above the distant sea level. This very peculiar but valuable deposit overlies the varied lava formation of this hill, and resembles the general results from hot springs; as mound-like contour of surface, absence of soil and vegetation, a white encrustation, and even thermal springs from the bottoms of the present deeper cuts. Boulders are found mixed with the more general mass, showing that the deposition was only in part from the hot springs' source, and must have been subsequent to them; and as the mud and sand of the interstices are still very moist and acid, and contain even profitable quantities of free sulphur, the action is still progressive.

The ground intervening the lake and hill is almost level, and from the summit it descends southerly, across the mineralized deposit, sixty feet in five hundred. The least dimensions for the ore ground have been placed, by four outside examiners, at 1380 feet long by 480 feet wide and 30 feet deep, and, after proper deductions for boulders, etc., they vouch its assay average value for quicksilver at $1\frac{75}{100}$ per cent. for the mineral portion, and $1\frac{1}{6}$ for the whole mass, or a total of 23,184,000 pounds of quicksilver. About 78 per cent. of this gross amount is supposed to be practically available, and after deduction of fifteen cents per pound, for excavation and reduction, leaves a net balance value of $9,000,000, with mercury at only sixty-five cents per pound.

Four things are necessary for the formation of cinnabar—mercury, sulphur, underlying heat, and interstices or cavities in the superimposed rock for condensation and aggregation—and when these are present, any bed-rock is suitable, but those previously enumerated have been most frequently and profitably mined.

California is doubly fortunate, for in addition to those of gold and silver, there are more than twenty quicksilver mines discovered, and during the last two years, the leading companies have realized the following amounts:

The Redington	25,494 flasks.	$405,202
The Sulphur Bank	30,849 "	311,018
The Great Western	14,266 "	140,425
The New Idria	17,846 "	191,659
The Guadalupe	18,952 "	253,250
The New Almaden	56,488 "	997,645

The last mine has been profitably worked for many years, having, like its namesake of Spain, gained a world-wide reputation, and although it has, in common with most quicksilver mines, shown dark phases of comparative poverty, yet, by chance exploration, profits have so frequently brightened their path that its financial failure may, even now, be remote.

These mines are quite distant from each other, and there are very extensive zones of just similar rock formations to those previously described, which are most interesting fields for intelligent prospectors. During the recent short period, when mercury obtained a much higher price than now, several mines were discovered, and it is more than probable that many more are still lying but slightly concealed.

The more favored modes for the reduction of mercury will be fully described and illustrated in the second volume, on Mining and Metallurgy.

OTHER MINERAL DEPOSITS IN STRATUM.

The numerous mines worked in the suitable limestone lead measures of Wisconsin, afford another variety of such hidden irregular pockets, where veins proper form no direct or indirect feature of, or cause for, their riches; and where unguided blind chance must stumble upon the prize, by dint of industrious perseverance and search by random drifts, in the supposed more congenial portions of the stratum. A deposit of galena being found and worked out, the threads, seams, or small pipes, of mineral, or indicative stains, are then often followed, which sometimes lead to other similar deposits. These have been mostly found in the naturally stratified rock formations; but we have many instances in this more western country where very thick reefs of tilted strata have produced large quantities of mineral, and one particularly remarkable instance in the State of Nevada of the large mineralized reef or zone, from which the Eureka and Richmond mines have obtained their rich argentiferous lead ores, and considerable profits.

It appears from recently afforded legal evidence, that their general excavations, beside, within, and across the great breadth of the reef itself and through the ore ground, have clearly shown that the mineral extended hither and thither to every direction in most irregular deposits, which sometimes lay for short distances by the side, but more frequently interlaced the general bed-rock of the reef. In this case it did not appear that the minerals either showed the usual book-like laminations of veins, or that they were contained in, or surrounded by, the ordinary vein matrices.

In such like formations there may be a more or less general percolation of gases and waters, and consequently, connections by very small and obscure, natural pipes and seams, must also prevail; but they do not show any other resemblance to regular veins.

The large surface deposit or open basin of carbonate of lead, worked from an exposed cut or quarry, at the Montezuma mine, Humboldt county, Nevada, and many other such deposits, were similarly formed and deposited in chambers or caverns beneath the surface; but they have been subsequently exposed by denudation.

The rock formations of Cornwall are probably as regularly deposited and well settled as can be seen in any other part of the world, for it is composed of granite and slate, with occasional feldspathic patches, being quite free from either the lime or magnesian rocks or volcanic invasions, yet even in such a formation very extensive excavations by ancient miners, of richly mineralized strata, have left us two exceedingly large surface basins, the one called Gwennap Pit, near Saint Day, where religious meetings are held on celebrated days, and the other the Navvy, at the head of my native valley, Porth Towan.*

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* Before closing these chapters on mineral veins and deposits, I would record the following ideas, which may, some day, be more fully recognized and established:

Organic matter, in decomposing condition, is generally present in silicic acid and other earthy solutions, which, when *passing down through the veins and pockets*, may serve as the very important *reagent* for simultaneously releasing and precipitating the silica, alumina, lime, potash, &c., with the gold, silver and base minerals upon the dualistic, lamellose aggregations of the veins, and in the above more irregular deposits; in a manner *differing only from petrifactions*, by the *equally disseminated weak solutions* of organic and inorganic elements, causing *the cleaner and more regular quartz-like deposit.*

SECTION II.

EXPLORATION.

CHAPTER I.

PROSPECTION.

From time immemorial, it has been the first duty of the miner to explore or prospect the surface of a country for minerals and metals, and for many ages this convenient source must have yielded a sufficient supply for the limited demands of the ancients; but, after some thousands of years had passed away, men discovered, not only more metals, but very many uses to which they could be applied and rendered eminently subservient to their varied purposes, the most wonderful of which are the printing press and the daguerreotype; the power loom, the steam engine and the electric telegraph; magnetism, galvanism, and chemistry. It is, however, during the last century that their developments and consequently useful powers have far surpassed all previous ages; for the steam engine has modified the maxim that "heavy bodies are slow to be moved," and the electric wire has more than realized the poetically wild expression of Shakespeare, by "putting a girdle round the earth in forty seconds."

Is it not most deplorable that these astounding strides of science should also mislead mankind into gross swindles and heinous inhumanities, as this greatest of all legal wrongs, the "diamond drill," when used by *rich managing trustees* for tapping the quality of mineral veins, for *first* and *exclusive information* *against the poor and helpless, but more numerous stockholders;* and that diabolical weapon for modern warfare, the "torpedo," now actually approved and allowed by intelligent peoples?

The first is worse than highway robbery, having no excusing feature, and should be immediately suppressed by an especial law. The second is a disgrace to civilization, and all nations should join hands to stop such scientific multitudinous murders. The present vessels for metallic armaments are so ponderous and expensive, that the muscles and products of peace are greatly wasted in preparing these iron-clad monsters for war.

The metals are not only a necessity for, but should be an actual measure of progress; for it cannot be denied that the country which possesses the greatest weight of manufactured metal per man, has attained a corresponding degree of influence in the world, which cannot be perpetuated without an inexhaustible supply; it is, therefore, imperatively necessary that we should economise by every available systematic means, to render these ruling commodities cheaper than they can be supplied from elsewhere.

It should be a matter for appreciation, that the inhabitants of this country have not only a *present available profusion* of these most imperatively necessary *natural materials* for a great nation's immediate prosperity, but that they have such vast quantities, more particularly of *coal and iron*, as to insure *continued success* in the future, even long after other leading nations have waned from prosperity by absolute deficieney of such supplies. These, under ordinary historical rules for advance, should naturally place this country, in the not distant future, far ahead of all others.

Remove the metals from the world, then knowledge, power, and the glorious light of civilization, will be so obscured, that men will stagger through the hopeless gloom of ensuing ages. In modern mining, the business of exploration becomes again the most important of all the phases of the miner's practice; for preliminary judgment governs the after success or misfortune by the wise or unwise selection from mineral veins. To be a good prospector is, in itself, a business that requires many qualifications, as well as much study and practice. Constitutionally robust and enduring, he must be as wary as the Indians, and accustomed to their ways; [illegible]od shot, cool as a statue and brave as a lion, in fight; he should be an able rider, and familiar with the management of horses, under many, ever-varying circumstances, to be anticipated at daylight for realization at night, as water, feed, safety, etc., for the animal and himself; and lastly, but certainly not the least, a very good plain cook, and a small eater. If not in possession of such qualifications, he had better stay within the more tranquil and congenial pale of civilization.

No one can admire the steady courage, energy, and firmness of such men more than I do; but their judgment and discretion must be kindly questioned and deprecated, as it is, indeed, for many reasons, a most unprofitable and thankless business; but, as the London *Times* once truly said, " mining infatuates more than it deters," and you will therefore run chances — perhaps for the good of ungrateful mankind—but we hope for more than average personal success.

The New York *Times* has also recently circulated the following pertinent remarks on agriculture and mining:

> " Despite the immense yield of gold in California, it is now shown that her tillable soil produces more actual wealth than her richest mines. Her grain and her fruit exceed in value the best of her placers. Her grape crop this season will be so very large that preparations are being made to convert one thousand tons of grapes into raisins. Most persons think of California only as a gold-bearing State, and it is pleasant to know that her agricultural resources are beyond those of her mines. Agriculture is apt to pay better than gold or silver-seeking in any fertile, well-cultivated region; but *there is a sort of fascination about the precious metals that allures men the world over*, and blinds them to more rational and legitimate branches of industry. It is said by those in a position to know, that not one man in fifty who has dug for gold on the Pacific slope has procured any considerable amount. Fortune-makers for the most part have been, and are still, speculators in San Francisco and Sacramento. A great majority of the men who have gone to California for gold, from 1849 to the present time, have not, it is declared, secured as much as it cost them to reach there and return. The hardest possible way to obtain gold is to look for it in the ground. It is generally much easier to get it by staying away from the mines."

CHAPTER II.

HOW TO EXPLORE.

To obtain a suitable outfit is the first duty of the prospector, and the following list of articles and suggestions may be of some value to those uninitiated in this sphere of life:

He should have two pairs of thick blankets, a buffalo-skin, or if possible, the more luxurious comfort afforded by a pneumatic rubber mattress and pillow, which are very light, pack closely, (after the exhalation of air,) and, by protecting the body from the emanations that arise out of the damp ground, prevent disease by increased accommodation. Two strongly buckled leather straps, for securing blankets, mattresses, etc., when packed for traveling. A suit of strong gray clothes, a change of flannel underclothing, a slouch cap, and a strong pair of boots. A Henry or Spencer breech-loading rifle; a full-sized Tranter's, Smith & Wesson's, or Colt's six-shooter; a leather holster, with waist-belt, and a good hunter's knife. A mule, or a mustang horse, accustomed to mountain life; a bridle, having a short whip attached; a horned saddle, fitted with rings for securing blankets, saddle-bags, water-canteen, etc.; one of the stirrups (I prefer the left) should be fitted with a tube for receiving and supporting the muzzle of the rifle, the upper end being suspended by a leather yoke, so riveted at its middle that one loop can be tightened on the taper rifle stock, and the other passed loosely over the saddle-horn, that it may be freed for immediate use when necessary. This same yoke can be used for "hobbling" the animal at nights, by punching two holes at a suitable distance from the ends, to allow sufficient freedom to the legs, when securely tied with buck-strings, through these holes, and then stop-knotted, so that the animal shall not stray too far away, when the scattered pasturage prohibits the use of a picket-rope. A small "poll" pick, and a light and solid wrought-iron baking-dish, of the shape of the prospector's pan: to be used, as required, for either purpose. An eight-inch wrought-iron frying-pan, a coffee-pot, tin cup, fork and spoon, a good supply of matches, some soap, a towel, etc. A blow-pipe, with suitable tools and fluxes for testing and assaying.

These, with a pocket compass and spy-glass, constitute a first-class prospector's outfit, and with such, (excepting only the buffalo-robe, mattress and pillow,) the writer has made a lone journey of eight hundred miles, over fourteen ranges of mountains, in thirty days; cooking bread and victuals, *en route*, from the following provisions: flour, fourteen pounds; bacon, eleven pounds; tea, one-half pound; a box of yeast powder, with pepper and salt. These, varied and assisted by two jack-rabbits shot on the way, desserted with good digestion, were more relished than better food would have been under less active and invigorating circumstances.

It would be folly to attempt a minute description of the general subtleties of sage-bush cookery, as most men will succeed therein as well as I did, and will be enabled to get on sufficiently well to prevent starvation, (if not to realize the value of tasting grief, that they may learn to live more contentedly afterwards) and necessity will dictate many varying dishes, by roasting, frying, and stewing.

There is, however, one suggestion that may enhance comfort, when passing through an unusually dangerous Indian country, when fires must be avoided at or near your camping-ground, and cold collations become a consequent necessity. In such circumstances, I boiled, when in security, one-fourth of a pound of tea in a quart of water, for ten minutes, and after removing the leaves, continued the boiling of this strong tea-water until it evaporated to about a pint, which I carried for use when required; it will be found that one spoonful of this, when added to a cup of water, makes a much more palatable and refreshing beverage for washing down your frugal meal than water, and it will prevent the headache that will otherwise result. A good remedy for the headache, in still more dangerous journeys, is to chew either of the agreeable and nourishing herbs tea or coffee, as many do the useless and disgusting weed tobacco.

This, being under peculiar circumstances, was worse fare than such men generally enjoy, and as I was alone, and traveling over strange ground, my poor, unfortunate animal, even thus freighted, with self, supplies, etc., had to pack two hundred and fifty pounds thirty miles per day, under a scorching sun, over mountains and alkaline flats, partaking of her scanty fare of chance bunch grass, during the night, most miserably restricted by hobbles. Mules have been much extolled for this work, and they may be better on the hard mountain; but, for the general purposes of exploration, the good, hardy, enduring mustang, if free from vice, is not only faster, but much easier for the rider, and on soft ground travels freely, where the mule, sinking deeper from insufficient area of foot, is retarded at every step; moreover, the mule's back is so ridiculously too straight for the requisite stability of the saddle when traveling over undulating country, that this alone would favor the use of the horse. As to their comparative measures of amiability, neither can claim much superiority, for the old saying of "Stubborn as a mule," may be equaled by a new one, "Wicked as a mustang."

These desirable equipments are often curtailed by a deficiency of cash, and those that are imperatively necessary are selected at discretion; but, in no instance, (unless prospecting for a lunatic asylum,) should he expunge more from the list than the horse or mule, with their appendages; the buffalo-hide, rubber mattress, pillow, one blanket, and the rifle; then he should, if possible, obtain the substitute of a faithful donkey, to pack his baggage and share his solitude.

Before moving yourselves away from water and grass, it will be necessary to resort to your most superior judgments for the whereabouts of the next suitable camping-ground, which I have seldom failed to anticipate from the following considerations:

In viewing a distant mountain, take particular care to measure with the eye the extent of mountains slope that is drained by any particular cañon; for, the greater the expanse of such surface of drainage, the more likely you are to find water. Granite, by absorbing less, yields more surface water than clay slate, and clay slate more than limestone. Snow-capped mountains are more to be relied on, in such positions, than those that are uncovered. Patches of willows, cottonwood, wild oats, rye, and other greens, indicate, by their extended growth beyond the mouths of cañons, the presence of water, which may be often seen at great distances.

Water frequently runs, during the night and early morn, much farther down the flats than after the sun's meridian heat has evaporated a portion of the running stream and its upper tributaries; so that, in apparently dry rivulet bottoms, moisture if not water, may be found a few inches under the surface, showing that it has recently run thus far, and the probability that it still flows a little higher or nearer to the mountain gorge.

Where water runs, grass will also be almost invariably present, in sufficient quantities for transient feed. If darkness should overtake you before reaching such a cañon, your animal will find water, by superior instinctive faculties, if unrestricted by reins, much sooner than you can.

It may be occasionally necessary to ascend a mountain that is deeply covered in snow, to examine some prominent out-crop; and if you have not the regular ten feet long by four inches wide snow-clog, you can readily make a substitute, by interlacing a few willows to form a support of two feet long by one foot wide, with holes in a suitable midway position for securing them under the shoes or boots. These will bear you up in very soft snow, and are much more easily made, carried and used, than the others, which require considerable practice, for much advantage.

In making the last-named snow-shoe, it is better to round off the outside corners and finish to the shape of a half-moon.

In cold weather traveling, it will also be very necessary to resort to extra artificial means for keeping the hands and feet warm, and a pair of kid or buckskin gloves or mittens, lined or covered with flannel, will be ample for the hands; whilst a barley sack, cut into rectangular halves, wrapped and tied around the boots, will be superlatively effective in preventing the feet from becoming cold and frost-bitten. If you have no cord for securing the half-sack, you may first cut the sewing of the barley-sack, and then, after cutting it straight through its longest diameter to form two triangles, they may be bound around the boots, then secured under the hollow of the sole, and over the instep, by knotting the acute-angled ends of the canvas.

Being thus prepared, the important questions arise: Where to prospect? Which formations should be sought? And what should be avoided?

CHAPTER III.

WHERE TO EXPLORE.

There are but very few general rules in mineral formations, and in many instances those which were once conformable to rule have become so modified and disguised, by extensive volcanic action, that original features cannot be recognized; under these uncertain circumstances, they can be valued only for what is immediately in sight, in such limited irregular and scattered pockets of the base minerals, and when combined with the other requisite facts, at more remote distances from volcanic heat, in the interior of primitive and secondary formations, for more profitable quantities of the precious metals.

The history of the world's mining has however, most clearly demonstrated this very important fact, that all of the great systems of true fissure veins, of the extensive and profitable mining districts, have been discovered and wrought in close proximity to, or within a few miles of, the junction of the primitive with the secondary formations; sometimes in the former, at other places in the latter, and frequently in both strata.

This principle applies more palpably to the older, less disturbed and regular formations, of the reactions produced in the true fissure veins of Nature's laboratory, and to gold, silver, copper and tin deposits.

Gold and silver, though strictly conforming to this position, appear to require the additional assistance of a partial disturbance by somewhat closely approaching lateral or underlying volcanic heat, to collect and concentrate their atoms, by some means (little understood); whilst the same power appears to lessen the previous deposits of the volatile base minerals by dispersion.

I have never seen a profitable mine for either lead, antimony, zinc, mercury, or the other very fusible and volatile minerals within the distance of two miles from any primitive range, and then only in transverse veins to that formation, and the other veins of the district; but, with very few exceptions, they are found ranging from this distance to some few miles away. It should be remembered that very small patches of primitive rock, accompanied by the appropriate surrounding conditions, have produced some of the most extensive ramifications of rich veins in the world; so that very large primitive mountains need not be always present, or comparative mole-hills be despised; for where such arise in the congenial clay slates, or in metalliferous carbonates of lime and magnesia, there you should most delight to sojourn for prospection. Such hills, in Cornwall and elsewhere, have produced in their immediate localities, near their junctions with the clay slate, in both these rocks, enormously rich and lasting mines. (See cut at page 77.)

In the United States of America, there are four very extensive and interesting mining fields west of the Mississippi Valley: the first of which commences at, and continues from, the Guadalupe and Sierra Madre of Mexico, and passes, in a northwesterly course, through the Territory of Arizona, by several somewhat broken, parallel, primitive mountain chains, the principals being the Chiricahui, Santa Catarina, Mogollon, and Pinaleno ranges of mountains, all of which are known to be surrounded by the various slates and other metalliferous secondary rocks.

Ancient records, miners' relics, and excavations, have been discovered all over the interior. Notwithstanding these demonstrations of past value, this country has been thus far but partially explored by modern miners, because of the persistent determination of the Indians to prevent the further encroachments of the civilized peoples on their country and hunting grounds.*

The second and still more inviting zone commences north of the Colorado River, where the Sierra Nevada rises and continues this northwesterly course for hundreds of miles in length, uplifting on its western slope the talcose clay slates of California, and on its eastern side numerous patches of clay slate and lime. This western slope of the Sierra Nevada is so well situated, for climate and proximity to the ocean, and so amply supplied with wood and general provisions, that it will undoubtedly become the most profitable, as it now is the most interesting and extensive, mining field in the world. For the reason of being generally covered with soil or alluvial debris, the greater desire of prospectors to penetrate the unexamined interior, high rates of wages, partiality of capitalists for real estate, high interest to be obtained for money, and being further damaged by reckless market mining, as well as by the more *ruinous practice of erecting the various reduction works* before the *mines were proved* by shafts and tunnels, with many other general extravagances from unsystematic mining, the mineral resources of the country have not been exposed. But the day is not far distant when, after many local notions are forgotten, and mining shall become the precursor of milling, that the quartz veins of this State will be worked as economically as those of Brazil, Australia, and New Zealand; and hundreds of ledges will then be reduced at a profit that are now unvalued and idle, which will lead to the discovery of thousands more.*

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* Since this was published in the previous editions, several good veins have been found in these remote districts of Arizona.

This range, after passing beyond California, bends to the north northeast, and continues, by way of Shasta Peak, Mounts Jefferson, Pitt, Hood, Rainier, Adams, St. Helen, and Baker, through the State of Oregon and Washington Territory, where similar analogy predicts mining success in the future. It then heads its several broken links to the north northwest, through British Columbia, and thence into perpetual snow; thus forming an almost entire line from Mexico, at about two hundred miles distant from, and parallel to, the coast.

When these northern countries of Oregon, Washington Territory, and British Columbia become more thickly populated, the dense forests of trees and brushwood will be cleared, and the country rocks more closely examined, in the rolling foot-hills and gulches of mountains which are now inaccessible.

British Columbia, (outside of its auriferous gravel,) has not thus far developed into a profitable mineral region, although it is almost certain that such a vast country will redeem itself in the, perhaps, far-distant future. The mountains where minerals

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* Since these and similar remarks were printed, the mines and mills of Amador county have been worked much more systematically and economically, by better mining, water power, rock-breakers, self-feeders, &c.

e likely to be found, lie at great distances from the sea coast,
d the country is so completely covered by trees, brushwood,
rns and mosses, that until trails are made by the Gov-
nment, it cannot be prospected. The principal mineralized
nes of the mainland, appear to be far east, even beyond Cari-
o, to the *north of, and opposite, eastern Idaho and Montana;*
iere the Rocky and Wahsatch primitive-mountains unite, to
t the secondary and mineral-bearing rocks. Vancouver island
pears to be very igneous in its general formation, but there are
veral large mountains, which lie in a lineal chain from almost
d to end, that should be examined, as they may have suitable
tings of mineralized strata lying upon their slopes.

I had a remarkably good opportunity of seeing the central
rtions of this island when examining gold-bearing quartz
iims on the head waters of the Ashlet river, which discharges
to Barclay Sound, on the western coast, as we had to actually
ilk 160 miles over dead logs, beneath the dark forest of trees,
ross the island, and thence up this river to the mineral site,
rough an indescribable profusion of ferns, mosses and "devil's
ubs." All of the island rivers produce gold, and this one, was
ing profitably worked by Chinese.'

The whole of Vancouver, and the hundreds of other islands
th their intervening waters lying between it and the main-land,
e extremely beautiful, and there are two things I must not pass
er without honorable mention, which are, first, the "Chinook,"
classical language of the various tribes of Indians and white
habitants; and secondly, the fact that we traveled in perfect
fety with and through Indians who were fully armed when we
ere not. This language was introduced for trading purposes
the Hudson Bay Company, and it has now become generally
iown by the old Indians, the English, and even the Chinese;
hom the Indians despise and ridicule at every opportunity.

I think the convenience for explanation by this jargon has
eatly aided in the civilization of these men, and the peaceful
cupation of this vast country by such an exceedingly small
mmunity.

The third field, the Wahsatch Mountains, commences a little
rth of the Colorado River, some hundreds of miles east from
d abreast of the second field, and runs north to confluence
ith the Rocky Mountains; forming the eastern primitive-rock

rim of the immense volcanic basin of Nevada—passing between it and Utah—the western flanks being, however, chiefly in the State of Nevada.

From the Sierra Nevada to this primitive's elevation of the secondaries, the country is, with very few exceptions, a vast belt of volcanic clinkers, in which extensive mining districts will not be discovered.

The both slopes of the Sierra Nevada have been too much neglected, to favor the more dangerous and less encouraging distant regions.

The mines that have been discovered east of the Comstock, (which is on the eastern side of the Sierra Nevada,) have been in connection with the few granitic islands that withstood this volcanic fusion, as the Austin Mountain, Battle Mountain, Trinity Mountain, and the mines at Unionville and Rye Patch, which are upon the opposite sides of the Humboldt Mountain, and within a mile of the primitive formation at Rocky Cañon.

The Wahsatch Mountains, having all the advantages of the various granitic and the older secondary formations, overlying its both slopes, as well as its numerous spurs, being of favorable acclivity, and of varying distances from this volcanic cauldron; some parts will be favorable for the argentiferous base minerals, whilst other places will have the more suitably remote advantages for the production of the precious minerals and metals.

It is also probable that, as eastward distance is attained, moderately thick deposits of coal and iron will be discovered, in the more central basins lying between these and the Rocky Mountains.

The fourth field is that formed by the Rocky Mountain, (which divides the water-courses of the Atlantic and Pacific rivers,) as it trends northerly from the southern portions of New Mexico, through the whole lengths of Colorado and Wyoming ; thence northwesterly, through Montana on the east and Idaho on its west, into British Columbia, where this mighty formation unites with the northern end of the extensive Wahsatch range and approaches and parallels the broken northerly extension of the Sierra Nevada, both bearing, as the coast, about north northwest. In this enormous length, the eastern slope will present constant variations, facing, as it does, such a vast plain, formed by the alluvials of all ages. Under such circumstances, it is probble that the various minerals will be found in far distant secons, along its serrated flanks, as suitable local strata may enourage their presence; and that heavy and frequent beds of oal will be found, transversely approaching in the alluvial loughs, at varying eastwardly distances, when remote from etamorphic action.

These are the genuine fields for such enterprising men, and here their indomitable perseverance will be more frequently ewarded by profitable mines.

After the discovery of the rich Comstock ledge, on the eastern erge of the Sierra Nevada, it was not strange that prospectors, vored by a magnificent climate, should have been infatuated, nd enticed forward into the far interior, for first examination f the unexplored land, that loomed, with all its distant and osy, enchanting grandeur, before them, as mountain after mounain arose, with irresistible enticements of apparent nearness and irgin nudity, that solicited and facilitated their exploration by he miner, to an extraordinary degree.

Under such unusually favorable circumstances, with hundreds f thousands of square miles of uncovered bed-rock, the wonder s, how little—not how much—has been discovered, by the money nd labor expended, in this part of Nevada.

The minerals that may have existed have since been fused, olatilized, and dispersed, excepting some few veins that laid in nd near the patches of primitive rock which resisted the progress f this igneous configuration.

The author has traveled through most of the portions of Euope, Western Asia, and Northern Africa, more particularly celerated for beauty and grandeur; but nothing in those countries an be compared to many parts of the vast interior of some reions of the Pacific States, more particularly when displayed to iew from the summit of a mountain somewhat higher than those round.

The atmosphere is so clear, that two hundred miles may be ooked through more distinctly than twenty miles on the sea-coasts f Northern and Western Europe; so that some scores of mounains may be seen at a glance, rising in grand sublimity, realzing all the shades of blue, violet, and purple of the painter, nd affording lessons in geology never to be forgotten.

This is pre-eminently the country for illustrating all the effects produced on earth by fire and water. It is very remarkable for the extremely rugged, disjointed, and serrated contour of the enormous quantity of irregularly washed, naked mountain flanks, which, trending northerly and southerly, like so many equi-distant, elongated, pyramidal islands, arising from an ocean ; the sand flats being all about the same level and alkaline appearance, whereon nothing but the wild sage and grease-bushes grow, as successors to the past seethings and conflagrations, and the hardy precursors of future vegetation upon the ruins of this vast cemetery, where, in these gradual uprisings from the ocean's muddy bed, fish, animals and forests grew and petrified ; now meandering rivers run but to sink into the volcanic chasms and debris of the past; a perfect panorama of geological illustration, exposing the wondrous diversities and tremendous distortions of the past and the fixed tranquility of the present.

Here may be seen, at one glance, a portion of an ancient ocean bed with its fossils, on the summit of the highest mountain; on the next intervening flat, an extensive petrified forest; innumerable and variously mineralized alkaline springs, as miniature water volcanoes; relics of extinct fire and water volcanoes, sulphur mounds, alkaline flats, with seas of frozen lava: amidst enormous more general upheaves, equally tremendous disjunctive shifts occur, which expose every conceivable form and color to the open day of a climate that, though too clear and dry for profuse vegetation, is most exhilarating and congenial for man.

Since the above remarks were printed, I have visited Colorado, and after passing down from Cheyenne, on the east of the Rocky Mountains, as far as Del Norte on the Rio Grande, followed up that river to the summit of the southern portion of the Rocky Mountains, and thence a thirty-five days' ride down to and over the rolling high table-lands of the southwestern corner of Colorado, lying at and around the La Plata Mountain.

This region has an equally good and pleasant climate, but having more summer and autumn rains than those described, the rolling country is distantly studded with a species of sugar pine, in an almost continuous park, of nutritious bunch and ring grasses. It is a magnificent region for surpassing beauty of mountains and plains, and, in addition to the frequent showers, is extremely well watered by many small gulch streams, and the five clear-water rivers, Dolores, Mancus, La Plata, Animas and lorida, which, after diverging for considerable distances, like a ide-spread hand, empty into the Colorado at distant points. t was once thickly inhabited by the ancient Aztecs, and is indeed paradise for modern prospectors and stock men. If a railroad hall ever be extended this way, millions of cattle will be raised or distant markets, at great profit. In reference to the chances or mining, I may say that vast areas of coal await men's requirements; and although there has been but little exploration for eins, many have been discovered, and some are of most promisng character. There are small scattered areas, still remaining n this district, which are eminently interesting for further prospection.

These four immense fields for mineral are still but very partially xplored, and possess unusual advantages. The climate is unurpassed by any similarly extensive region in the world, so that prospectors can sleep out with impunity, and incur little risk rom disease. The mountains of the interior, excepting those of Oregon, Washington Territory and British Columbia, are generally bare to the bed-rock, and invariably so in the gulches, which afford superior facilities for prompt examination.

The present elevation of the low, flat grounds, constituting the bed of an ancient ocean's debris, as washed from the mountains during the gradual changing of the level of this region, now varies from about 3000 to 4500 feet above the level of the sea, and affords natural roads for traveling in any direction from mountain to mountain; whilst their foot-hills and extensive cañons generally supply more than sufficient bunch-grass and water for he animals.

Another advantage is realized from the fact that animal food may be kept for an almost indefinite time, without being salted, even during hot weather, because of the extreme dryness and rarity of the atmosphere.

It is, moreover, free from malignant diseases or dangerous wild beasts, and the Indians generally prefer giving civilized man a wide berth.

In mining, it will have the advantages of high reserves of mineral in the mountain veins; and for this reason, the lack of rain, and that of the general fact of a peculiar disposition of the water to sink deeper in this elevated and disjointed country, large pumping engines will be seldom required; whilst wood is generally found in sufficient quantities for hoisting, milling and sme ing the ores. The disadvantages are, remote positions from sea, which in one belt is already modified by the completion the Atlantic and Pacific Railway; other railways will in time low, to benefit the different transverse belts through which th must pass. This distance, with the present high rate of wag etc., will prevent the successful mining of base minerals by co panies. Gold and silver will, of course, if in quantity, overr these difficulties, and can be mined anywhere at a profit.

Small bands of miners have sprung up, on both sides of Atlantic and Pacific Railway, that give this matter quite a feature, which is that of poor, industrious prospectors, work their own ledges, and forwarding the ores in suitable quanti to a San Francisco, or other distant market; saving many penses, and thus realizing, in some cases, a satisfactory amou for their labors on ledges or from pockets, that would utte fail in the hands of larger, more expensive and cumbrous co panies, working for such profits as mines should realize, to rei burse preliminary expenditure, and yield commensurate di dends, for greater expectations.*

In the first three centuries after the discovery of America, o hundred and sixty thousand tons of pure silver were expor from Peru and Mexico alone. The Potosi mine, which has yie ed enormous quantities of silver, is at an elevation as great that of the summit of Mont Blanc, in a region of perpetual sn The mines of Mexico are on the plateaus and slopes, at medi elevations, where neither frost nor great heat prevails. The mineral wealth of Peru has been developed by the patient ind try of the Indians, who are very strong and enduring, althou they live almost entirely upon cocoa, and their wages aver only about $1.50 per week.

A very romantic story is told of the Salcado mine, which been lost for a hundred years. Salcado was a young Spania who fell in love with and married an Indian girl, whereupon she revealed to him the location of a vein of fabulous richness, which he after seeing and making friends with the Indians, commenced work upon, and became in a few years exceedingly rich. The Spanish Governor, designing to secure the mine, caused a false charge of conspiracy to be made against him, under which he was arrested, tried and condemned. When awaiting execution he promised the Governor, De Lemos, that if he would allow the proofs to be sent to Madrid and be inspected by the king, there should be paid him a hundred pounds of silver every day until the vessel should go to Spain and return. Salcado, however, was executed.

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* Since these mineral fields were predicted in the first and second editions, many have been realized, as the rich strikes of Arizona; the excellent mines at Bodie, firs covered by W. S. Body, who afterwards perished in the snows of the winter of 18 those of other districts on the eastern slope of the Sierra Nevada; the mines on th ern slope of the Wahsatch mountain; the coal in the basin east of it; and the many able distant sections on the declivities of the Rocky mountains. Had poor Body prospecting for the North Pole—*folly of the age*—instead of mineral veins, he woul been immortalized.

The Governor hastened to take possession, but the mine was gone, and has never been found. The widow and her devoted Indians had flooded and buried the property in such a manner that discovery was impossible.

The richest silver mine yet discovered in the world is the Potocchi, or Potosi. It is near La Plata, and was discovered in 1545. It has always been worked in an antiquated and expensive manner, but yet it is said to have already produced $250,000,000 worth of the precious metal. For many years, sixteen hundred Indian slaves were employed in it. At the present time two thousand paid men are employed, and the mine shows no sign of exhaustion.

The total silver production of the world from the year 1850 to the present time has been estimated at $1,025,000,000. The United States produced one-tenth of the entire amount, and will greatly increase its yield as the outside districts are developed. The yield of Mexico is at present at the rate of $20,000,000 annually. Peru is falling gradually behind, the yield for the year 1874 being a little over $3,000,000. The mines of Chile and Bolivia are being rapidly developed, and will soon furnish a material item in the annual production. Nevada was not reckoned among the silver-producing regions until after 1850. Mexico and South America produced in that year $35,000,000 worth; nearly five times the amount obtained in the same year from Europe, Asia and Africa. The production of Piedmont in that year was greater than any other section of the eastern continent, and was about $1,500,000. Austria was represented by about $1,000,000, while

Russia, Norway, Saxony, Spain, the Hartz Mountains, and the argentiferous lead mines of Cornwall and Devonshire, in England, produced the remainder.

UNEXPLORED REGIONS FOR SUPPLYING GOLD AND SILVER IN THE FUTURE.

In addition to very many valuable veins which are lying in concealment within the limits of the districts that are now thought to be sufficiently explored, there are still vast and well-marked mineral-bearing areas, just as little known by the miner, as if they were situated upon the mountainous regions of another planet.

1. In natural contour of surface, and difference of elevations and formations, nothing can exceed, from analogy of values elsewhere, that of the eastern slope of the mighty Andes, which once formed the narrow continent, or perhaps at that time the island, of South America.

The western slope of the Andes is more precipitous and lies much nearer the sea than that of the Sierra Nevada. Its eastern declivity will be likely to more closely resemble California for both mineral veins and alluvial gold formations; for as the ocean waters receded, vast quantities of the mountainous shore would have been disintegrated and carried down by ice, snow and rain, and the long-continued dashings of the breaking waves from the wide Atlantic ocean; and it cannot be doubted that many hundreds of miles of ancient parallel bearing auriferous gravel must lie there, just now ready for the miner. The country, so far but partially developed on the Pacific side, has been pre-eminently productive of the precious metals. The eastern slope may be more readily approached by way of the Amazon and La Plata rivers.

2. The extensive and unexplored mountains and foot-hills of the East Indies and China.

What has been known, in modern times, of those regions, as regards minerals and metals, has been gleaned more from ancient indirect historical allusions than more immediate modern discoveries.

The governments should favor and aid prospections for the precious stones and metals, as these countries are not easily explored, being very inaccessible, because of dangerous wild beasts and dense jungles.

3. The mountainous sections of the interior of Africa.

I have noticed at several points on the northern shore some interesting formations, but although quite accessible, it has been scarcely examined for minerals and metals, either by the natives or foreigners.

The Cape of Good Hope portion of this continent so far as prospected, has yielded some good veins of base minerals, and still more extraordinary results in the diamond fields now being extensively worked.

The hot and unhealthy interior of the central portion of Africa, although it may be a very interesting country, can never be of much value to white men.

The southeastern coast of Africa, being mountainous, may afford a good supply when examined and developed.

4. Australia and New Zealand will be also likely to greatly increase their yields of minerals and metals, when more thoroughly examined and worked.

In concluding this Chapter, I cannot help reiterating the claims of the many noble men, who have by their heroic and indomitable actions brought millions to mankind without much, if any, benefit to themselves. In fact a sort of adverse fate has generally followed them, as Salcado, of South America, was cruelly executed; Comstock died miserably poor in Montana, where not even a headstone marks his grave; Body had his life's blood frozen in coming from the district bearing his name; whilst Marshall and others, yet living, are not in the least degree rewarded.

Governments may, very justly, reward soldiers for brave services, on battle-fields, but, by neglecting to also favor and recompense the works of such worthy men as these, they jointly injure both countries and men.

CHAPTER IV.

THE PECULIAR KINDS OF THE PRIMITIVE AND SECONDARY ROCKS WHICH CONCERN MINERS, AS BEING MOST CONGENIAL FOR RICH VEINS; AND WHAT FORMATIONS SHOULD BE AVOIDED.

In the preceding chapter, some generally observed principles have been analogized, as to the more probable positions for the profitable plenitude of the minerals of this country; which I will now endeavor to still better explain for the practical guidance of prospectors.

It has been previously stated that the extensive and profitable mines, throughout the world, have been found near the junctions of the various primitive and secondary strata; in the former, or the latter, and sometimes in the both; and although this is literally true, other collateral causes must be also present, to create the fissures, and supply them with the several elements, and their solvents and precipitants, or minerals will not be deposited therein.

For instance, a granitic range may pass through and uplift, on either slope, hundreds of miles of secondary rocks, neither formation having veins; or, having them, the minerals will be insufficient to pay for their extraction; but suddenly certain changes will present indications to the eye of the miner, that will induce him to halt for more careful inspection.

Again, the prospector may travel entirely across a compact, stainless, primitive mountain, as the Sierra Nevada, from the eastern verge of the Californian system of auriferous veins, without seeing a lode, until he reaches the appropriate formations on its eastern slope, as at the well known districts of Virginia and Carson, Bodie, Belleville and Cerro Gordo.

Granite *proper*, with the *three* ingredients of quartz, feldspar and *mica*, is the primitive rock of Cornwall, and many other noted mining regions; but I have never seen it in any of the States or Territories of America, either lying upon or west of the Rocky Mountains. Syenite, composed of quartz, feldspar, and *hornblende*, appears to take its primitive positions in this country, and where the tilted and metamorphosed secondary rocks are also suitable, a great many very good silver mines have been found.

It must not be supposed that these are the *only* primitive formations which are congenial for mineral, as even true syenite is comparatively rare, and both varieties of these speckled rocks must be often qualified by such terms as syenitic, and granitic, or be more directly defined by individually naming their several constituent parts.

My experience of mineral-bearing primitive mountains, after knowing that the "country" or "bed rock" formation has not been produced by subsequent volcanic invasion, is, that if the rock is largely composed of *feldspar*, it is quite immaterial whether mica or hornblende is present, and quartz may be almost or even entirely absent; provided also that the rock has been sufficiently crushed and disrupted into joints, by lateral pressure, to produce the necessary metamorphism for such deposits.

The questions now arise, as to what additional appearances, modifications, and transformations, should also be sought in these strata? In this connection, there are five very valuable indications; the first and most important being what will be better understood as *broken ground*, or partial disruption, disintegration, and decomposition of the stratum, where frequent crumblings, distortions, and fractures, show that sufficient force has been in action for the creation of veins, and shattering the surrounding bed rocks, for the free percolation of mineral waters, as well as greater freedom for the decompositions of those rocks which may contain their precipitants.

The centers of extensive primitive ranges are naturally very compact, and water-tight; and, consequently, veins and minerals are seldom found in such elevated and primitive positions.

Secondly, it is advantageous to, and characteristic of, mineralized districts, when reefs of variously compounded rocks interlace and distort the primitive, transition, and secondary formations, by curvatures, shifts, and slides ; and the more so, when they range at varying angles, and give evidence of different ages of such disruptions.

Thirdly, for gold it is an invariably favorable sign, as it is sometimes of silver, when the upheaved talcose, micaceous, and argillaceous clay slates are much folded and tilted, even to the vertical, for long distances, from their originally horizontal position, and when the *very lowest foot-hills* and ocean-ward flats show the presence of the *oldest* fossils of *salt-water* shells.

Fourthly, a moderate amount of the stains from the oxide of iron, generally disseminated throughout the stratum, and mixed with the sulphuret of iron, in and near the vein, are excellent guarantees for the presence of nearly all of the metals, and metallic minerals; many of which are never found away from its influence or out of its company.

And lastly, that which will be almost impossible to describe, although as much heeded by the miner as the soil is by the farmer, consisting of a peculiarly congenial and prolific stratum, and a correspondingly generous, maternal nature of the quartz, from the veins, as well as a fresh, pregnant ripeness, of the minerals themselves; as if but just arrived at complete strength, ere they are again dispersed by nature's solvents.

These indications are designated by miners, "kindly ground," "sugary spar," and "rotten ripe;" the reverse being "ugly, unkindly ground," "hungry country spar," and "dried-up ore:" each particular meaning being well understood by the miners, and acted on during their practical lives, to assist them in arriving at the more profitable sections of veins; during their very speculative excavations upon "tribute," or fractionally rewarding, contracts.

To describe the rocks which should be avoided, when searching for minerals, is an easy task. In the first place, it is unadvisable to go far away from the *junctions* of the transition or secondary with the primitive rocks, or to penetrate the interior of the more igneous volcanic regions, where these imperatively essential, mineral-bearing rocks, are absent.

Secondly, all extensive areas of *porous* volcanic bed-rock should be despised, for deficiency of veins, and paucity of minerals; for, although it may be said that the *native copper* mines of Lake Superior are in amygdaloid, this is a solitary exception, where volcanic fire may have sublimed the minerals that existed in pockets or veins prior to such invasion, for subsequent precipitations into metal. I know of no other instance where *metallic copper* is found in veins that are entirely *destitute* of the *minerals of copper;* and therefore it does not conflict with these rules for mineral deposits.

Thirdly, the modern carbonates of lime and magnesia, and clay slates, that enclose well-defined and comparatively *recent* shells, seldom produce veins with sufficient minerals to pay for extraction; excepting rare pockets of silver, and the ores of lead, iron, coals, etc.

Fourthly, avoid too close proximity to extensive deposits of mineral, the property of others, as the largest bunch has its limits, and sufficient space must remain for the accumulations of the metallic elements or precipitants, before another considerable body of ore can be deposited ; it is generally better to go a few hundred feet, and often, miles away from, than to mine in close proximity thereto. The history of great discoveries has too frequently shown a debit balance from such districts by this very indiscreet practice.

And, lastly, to guard yourself from becoming too much attached to your own ledge, mine or district, by discarding sanguinity, and searching for defects and poverty; not forgetting these patented facts, that deposits fail much oftener than they continue rich, and that very many blanks must be expected for one prize.

As an illustration for exposing the folly that minerals are equally disseminated, or that riches must generally extend because a mine or two has been profitably worked in a district, it may be interesting to the reader to know, that the county of Cornwall, England, is altogether but a mere speck, forming a near approach to an isosceles triangle, on a base of only forty miles, and about one hundred miles from base to apex. Small as it is, as a whole, not much more than one-hundredth part has been proven to be profitably mineralized, which is not in one particular district, but lies in a few small spots; the intervening ninety-nine parts being, so far as known—after a thousand years mining for minerals that for many generations almost supplied the world—as worthless as any other unmineralized country. The rich districts flank and surround small but genuine granite hills, or are near thereto in basins of "killas," which is a very peculiar kind of rotten, disjointed, and but slightly stratified argillaceous clay-slate, of very different appearance to the outlying, non-mineralized and more stratified clay-slates. These districts, commencing at the apex, are the St. Just, St. Ives, Lelant, Marazion, Huel Vor, Wendron, Gwinear, Cairn Brea, Gwennap, St. Agnes, Perran, Chiverton, St. Austle, Fowey Consols, Bodmin, Liskeard, and Callington.

The adjoining and much larger county of Devonshire has yielded minerals in similar but still less general manner, as there are but two very noted districts for copper, headed respectively by the Great Wheal Friendship and the Great Wheal Maria Mines, and only two, remote districts for lead, as the Gunnislake Mines near Saltash, and the Exmouth Mines near Exeter.

It should be remembered, that even these small and closely situated districts have individual peculiarities of formation, characteristics of strata and indicative matrices, with many varieties of deposition and modes of occurrence of the minerals in their relative positions.

CHAPTER V.

THE LOCATOR'S PRELIMINARY EXPOSITION OF THE GENERAL FEATURES OF A VEIN, SO AS TO ASCERTAIN ITS APPROXIMATE VALUE.

After the location or preëmption of a vein, it is imperatively necessary that a certain locally regulated amount of work must be performed, within a specified time, prior to its being placed on record, so as to secure legal possession; and this work should be executed for the more useful purposes of ascertaining the definition and value of the located ledge; but such has not been the practice, for it has generally consisted of an open cutting through the softest place, so that the required number of cubic feet could be excavated in the softer " bed-rock," with the least possible trouble to the discoverer, ignoring this or any other really useful purpose.

Had the law demanded that the first columns for marking the discovery should be superseded by other columns of rock, broken from the ledge itself, within the usually specified time for the excavation of cubic feet, this would simultaneously accomplish an actual examination of the vein, at one or several points, which could be still farther systematized by taking the matrix vein stone from a hundred places all over the back of the lode, and, after breaking ten times as many small sample pieces from all the corners of each of the monumental stones, it mght be treated as follows for examination and value:

Crush all the pieces thus obtained between two hard flat stones, to the size of peas, and after collecting all of the debris, coarse and fine, and mixing them as intimately as possible, take therefrom two portions of about one pound each; the one you may pulverize as fine as your convenience will allow, and treat by water in your prospecting pan, baking dish, or horn spoon, for gold, or for the nature, quality or quantity of the heavy residue;

and then, if this test is found to be encouraging, forward the other portion to a professional assayer, so as to ascertain its exact value.

This will be more fully and correctly described in Section III. Chapters I and III, for those having the portable prospector's "Wee Pet" assaying machine, or other suitable apparatus, to finish the assay upon the spot.

The most absurd and frequent practice of single stone samples cannot be too severely ridiculed; for it would be just as reasonable for a geologist to land on a strange coast, and pronounce the whole country similar to what he saw beneath his feet; or as correct for a burglar to enter a general hardware store, during darkness, and, bringing the first thing he handled to the light, to say that the whole store was stocked with pestles and mortars.

This more systematic and rigidly correct method for averaging its quality may expose the ungarnished truth, and damp your ardor; but if you will still work the wires of deception, it need not debar you from the diabolical and too prevalent practice of selecting the best specimens that you can find from the more favored parts of the vein for city exposure, to directly mislead *them*, and draw the finger of scorn, with ultimate ruin and disgrace upon *yourselves*, and mining.

It frequently happens that ledges disappear under the soil and surface debris; and, when such hide the vein, it may be found by what has been called in Cornwall "costeaning," which is simply a search for the back of the lode, by a right-angled cut, or a few transverse pits or hollow shafts, to attain the "fast," or bed-rock, and sometimes the vein or its relics, unless it happens to lie between these excavations, when it is discovered by a level driven partially in the bed-rock from one to the other shaft. In the absence of better proof for its position, a straight line may be drawn over its bearing where last seen, and suitable allowances made for local contour and influence of the enclosing stratum or strata. For example, we will suppose this direction line runs due south over descending ground, and the vein dips east, or to the left, at 45°. It will be only necessary, in such a case, to take the difference of altitude of the known and unknown parts on this side of the vein, and to measure towards the east, or left hand, its gain from such dip in that direction, which, in this case, would be exactly as much as the fall, or difference of height, of the two places.

This will also apply for rising ground, by reversing the measurement to the right.

You will be assisted in these calculations by referring to the illustrations on pages 105 and 109.

In some positions, a sign of moisture or springs of water may be also advantageously noticed, to facilitate in finding the exact position of emergence.

Before the final registration of your claim, see that your lines of location run with the vein, and avoid lawsuits.

The Cornish grants of *oblong areas*, with *perpendicular boundary lines*, is more simple than following the vein with its dips, angles, spurs, etc., and much less likely to cause litigation after good mines are discovered.

You have now arrived at the most important stage of your avocation, and if your intentions are honorable, the greatest care should be taken, lest you deceive yourself in the average value and quantity of mineral required for a profitable mine, as many have done in days of yore. In this you will be much assisted by not only the advice offered in this chapter, but in those immediately preceding and succeeding, for general characteristics and systematic preparation of the sample previous to assaying for correct value.

By being sole owner, you will have the advantage of not having the schemes of dishonest tricksters to counteract, or an unscrupulous, interested "salter"—the terror of "Experts"—at hand to mar results.

I cannot withhold a most diabolical example of such, as practiced upon the public and myself at a mine that I visited—in a cursory non-official manner—some years ago; and will herein describe the dirty, disgraceful affair; for although covetous of knowledge, I would much rather be considered a fool than a rogue or thief, and therefore can still afford to join in this grin against myself, without, in the least degree, honoring the contemptible actors by more particular mention here.

When I first visited this mine, it was not, as just stated, for an official examination, but because of such highly-colored city reports from the manager, and the general talk of the people of an adjoining district, where I had been sent to examine another mining property.

My visit to this "Banditti" Mine was quite sudden and unexpected, but I was courteously received, (which was neither unusual nor improper,) and taken around to see the property, both above and below, without any formal introduction from the city office; and every person, from the superintendent to the cook, appeared to be as ingenuous as fat babies. You must also know, that the mine was in a bounteously mineralized section of the country, and only just then commenced to be opened out, as shown in figure 13, by the diagonal lines of the section, where the shaft and shallow levels, with communicating winze, are thus delineated, and distinguished with the black winze, *W*, as the work of the first Superintendent.

They had a very large pile, *P*, carefully laid out at the surface, of at least 800 tons, of what was, *all over its exterior*, remarkably good ore, and from which a carefully-averaged sample, assayed as well as could be desired, and they showed me very many equally good certificates from other assayers.

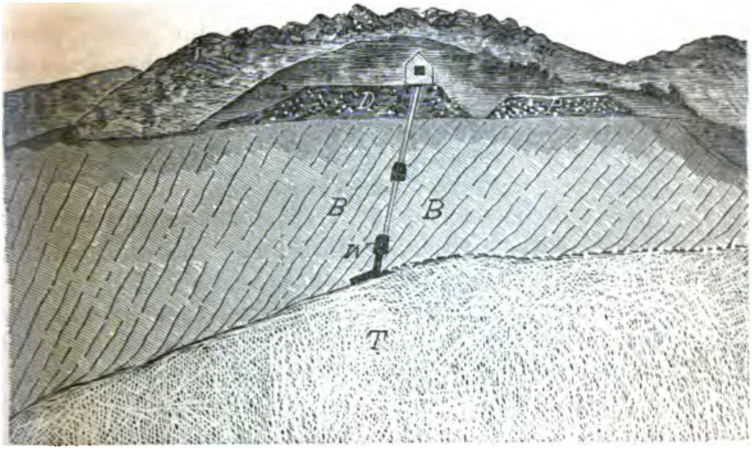
I went "under ground," as miners say, and in passing down the inclined shaft, saw as good corrugated walls to the vein as can be seen in any mine, but no ore of value either in the first very shallow level, the main shaft, or the communicating winze from level to level: but at thirty feet from the main shaft, in the wide lower level, there was a fine course of rusty ore, which extended for at least eighty feet in length, to about the winze, where the lode was but little mineralized, although as large and well defined as ever, and lying upon the same splendid wall.

This drift was in places over twelve feet wide, and all of a similarly rusty mineralized character to that at the surface; but not being engaged in professional examination, I took no average from the level itself for assay. It must, however, be admitted that I was pleased with the appearance of the vein, for it was less than one hundred feet deep, having this notoriously good indication of the corrugated wall, and was even so well mineralized, after every usual deduction, for the slight extent explored, that no man could reasonably doubt its being the top of a valuable "chute" of ore, and I placed greater confidence in it because I had examined valuable dividend mines, yielding a similar kind of ore, lying in the same rock and region, and within even far less promising lodes.

The mine had become quite a favorite in the market, and as it then stood low in price, I, in common with many others, thinking that it would be profitable, bought stock, but did not sell at occasional increase of market price, for as they were making a great fuss about the immediate preparations for the reduction of their ores, rather preferred waiting for developments at the mine and actual returns.

Next followed twelve months of *good reports from the mine*, and a long chapter of *failures in reduction*, during an unusually snowy winter, when it was stated that *no fuel could possibly be obtained from the mountains*, and that even the *bullion which had been reduced* was so "stuck in the mud" *en route* to the city, that it would be *therefore necessary to make an assessment*, and other consequent assessments followed, until the *victimized outside stockholders*, becoming sufficiently numerous, caused a change of management, and sent me forward to ascertain the true state of affairs.

Figure 12.



I was informed, on my second visit, that the 800 tons of ore lying at the surface, had only been a mere jacket of rich ore, covering a slightly smaller pile of worthless rocks, and that the manager at that time, (twelve months previous,) had sunk the winze (*W*) fourteen feet below the bottom level, in the center of the "chute" of ore, and after finding that the vein had been completely unbottomed by a *transverse* shift of *bed-rock*, since proven to be similar to the cross section, fig. 12; and after immediately filling it up to the bottom of the level, shutting the mouths of the men, and duly posting the Methodistical President, and chief owner, he commenced his game of deceptions.

It is the first instance of my long experience, where such a *well marked corrugated wall* has led to such *sudden and complete termination;* but it lies in a *much-disturbed volcanic* region.

The *Trustees,* being fully posted on the sudden loss of the vein, held a private meeting to discuss the manner of escaping from the dilemma, at the expense of the outsiders; and, being skilled in such matters, readily discovered the trail, and escaped from the woods in the following manner:

The first Superintendent must be satisfied and honorably discharged, even by taking his stock at the then good nominal market price, to prevent his spoiling their game, and a trusty man sent to supersede him, so that they might have time and opportunity for selling out on his reports; hence the duly arranged *good reports* and suitable *delays* described.

Figure 13.

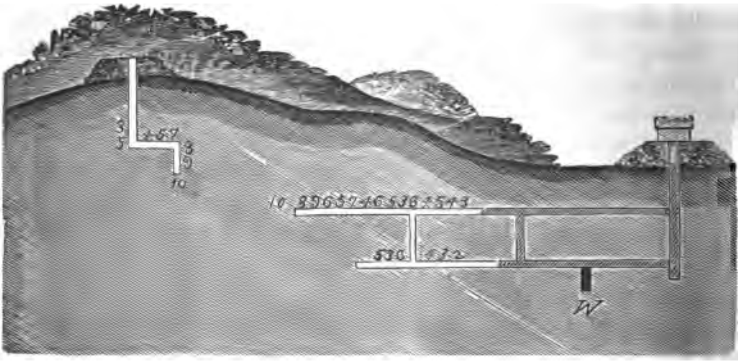


Figure 13 represents a section, showing by the diagonal lines, the position of the first "chute" of ore over the black winze *W,* and the extent of the mine as excavated by Superintendent No. 1, and the white shaft and levels with accompanying figures also expose something like the extended excavations and *daily number of tons of good ore* broken by the miners, as taken from the *twelve months' reports* of Superintendent No. 2.

At this stage of the sectional development, he also reported, that "*he saw no reason why the valuable run of ore* should not *extend to connect with that in the shaft,*" being sunk some distance ahead for ventilation and general convenience.

You will suppose that he had been opening a valuable mine, but I found no discovered ore of value throughout thirteen hundred feet of most ridiculous levels and shafts. I have been examining mines many years, have seen thousands of veins, and am as cautious as any one, (as all know who have witnessed my work,) but I must say that no expert would have expended a week's labor in overturning that 800 tons surface pile; or worked days in picking all along the bottom of that then advancing level, to search for *filled up* winzes; *even if he had full orders for examination.* No man should have held the opinion that the whole of the subsequent twelve months' reports, regarding great value, were absolutely false.

The small quantity of bright dust that has fallen on my path during life's journey, has been honestly collected, and I neither want more by bribery and stealth, nor would have the dirt kicked from my grave by injured survivors.

These "Rovers" have since played similar tricks elsewhere, and are still at large, seeking more plunder.

A *recent*, honestly-written article, by an indignant *local editor*, regarding *another mine* of theirs, says, after describing their abominable doings, that "It is putting it mildly to call those responsible for this state of affairs, swindlers."

In this example they had also been expending stockholders' money in a most reckless manner, in mining and engineering, by foolish levels and surface mechanism; the former would require an extra cut to show by a "working plan" the extent of their follies, and the last may be sufficiently exposed by my informing you that they had nothing better than the ordinary "hand windlasses" for hauling rock from such extensive excavations.

This illustration is just one of direct rascality, without any show of cunning or ability; but there are many other modes practiced by much shrewder men, which I am no more justified in exposing, than would those few eminent physicians, who are fully acquainted with subtle poisons, which cannot be detected after death.

CHEAP HOISTING APPLIANCES FOR SHALLOW MINING.

For the many that will proceed from prospection to actual mining, and carrying ore to distant markets, the following descriptions of different means for cheap hoisting will be very valuable, and may encourage them forward to success.

Prospectors are generally provided with a horse or mule, and unless they manage to arrange work for them at the mine, they are feeding or lying upon the surface in useless idleness, whilst they are themselves most industriously working beneath the ground.

1. The most readily applied mechanism by which you may obtain the valuable assistance of your horse or mule, is what has been called by Cornish miners, a "*Whipsidary,*" and of which there are two kinds, the *double* and *single.*

The "single whipsidary" will best suit your preliminary requirements, and may be sufficiently well explained without any illustration.

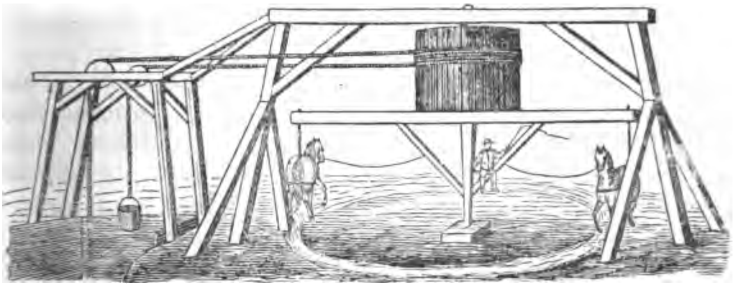
An iron or wooden pulley is placed vertically within the jaws of a two-legged stand, just sufficiently high above the shaft to land and discharge the bucket properly, when a sufficient length of rope is thrown over and attached to the bucket at the one end and to the horse or mule at the other end. A straight trail being made from the shaft pulley, the bucket may be lowered into the shaft, then filled, and directly hoisted, at pleasure of yourself and animal.

2. The "Double whipsidary" differs from the single, by having two vertical pulleys and buckets over and in the shaft, and a horizontal drum or pulley away back at the end of the straight trail previously described, for receiving and carrying the double of the thus tightened rope. The animal may travel upon one trail between the rope, and is alternately hitched on to the full bucket's side.

If the shaft is large enough for two buckets to pass, this is a cheap and snug, speedy and useful, well balanced arrangement, for very extensively developing and even profitably working poor men's mines.

3. The "Horse Whim" is sufficiently explained by the following illustration:

Figure 14.



4. The "Inverted Horse Whim" is similar to the above, but much of the upper framework is saved by burying the cage or drum beneath the ground, at the expense of friction, from the greater angling of ropes and chains, at the shaft.

The "single whipsidary" will hoist from a depth of about one hundred and fifty feet.

The "double whipsidary," being double and balanced, will hoist much faster and easier, and when well arranged, from two hundred feet deep.

The "horse whims" when balanced by large double buckets, will draw a much greater quantity from three hundred feet deep.

5. "Overshot Water Wheels" may be advantageously used, when an ample fall of sufficient water can be obtained within suitable distance from the shaft.

The wheel may be attached to the drum that carries the rope, so that it shall directly line toward the shaft pulley, and although it can be used for double draught by reversible gearing, it is much cheaper and more suitable for your requirements to use it only for single hoist with the power of the water, and then lowering the bucket by the friction of a hand brake, directly applied, on the rim of the wheel. In such an arrangement, the wheel and drum being quite small and light, may be substantially connected as one piece, and revolve both ways, by water and brake, as may be required in hoisting and lowering the bucket. A wheel of eight feet in diameter and three feet in breast will, with a suitable stream of water, do all that you are likely to require.

It will be advantageous, both for speed and convenience, that the governing levers for power and brake shall be placed within easy reach, and the water should actually fall about a foot into the buckets, to give a momentum or instantaneous force for starting more promptly. In this single hoisting, the water may be made to accumulate or "pool up" during the requisite time for descent and filling the bucket.

6. The "Reversible Overshot Wheel." If you have a surplus of water and a sufficiently long shaft, you may have a double bucket balanced action by the rope passing from over and under the drum to two shaft pulleys, by the simple construction of a twin wheel, whereon the buckets of the one may fill and travel away from, whilst those of the other shall travel towards the shaft when under individual draught, by changing the stream.

The description of a 46 feet wheel, which I erected in Cornwall, as used for double hoisting, may be seen in the Second Volume. The wheel was of the usual form, and the reversing was effected by sliding from side to side into suitable clutch boxes upon two out of three bevel wheels, geared to appropriate and continuous connection.

7. The "Single Percussion Wheel" may be applied when you have a small quantity of water and a high fall. It is in principle nothing more than a strongly built bucket wheel, as under heading 5, and may be very roughly but strongly made, about four feet in diameter and either of wood or iron. The water is very rapidly passed into the buckets from a small horizontal nozzle, as supplied from a vertical or inclined column, under a pressure as produced from a height of from fifty to two or three hundred feet.

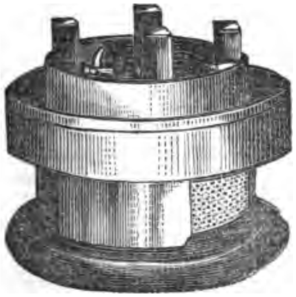
8. The "Double Percussion Reversible Wheel" may be understood by combining the descriptions in headings 6 and 7. These percussion wheels should also have controlling brakes.

Such water appliances equal the draft from only a few feet to almost any depth required by miners.

Other horse whims and steam appliances for deep mining will be more fully described in the *Second Volume*, on Mining and Metallurgy.

If after a thorough examination, you think the vein is worthy of being developed, it will be your immediate interest and duty to ascertain what natural advantages the region will afford, as to climate, good water, cattle feed, wood, etc., and cost of carriage of supplies from, and ores to, the market; not forgetting the important fact if the road is generally descending, and free from adverse hills or "steep nips," which greatly tend to lessen the "through load." It will also be very important to obtain streams of water for costless powers, so as to secure some one or more of the valuable mechanical aids just described for your present lighter uses for exposing the merits or the actual working of the mine, as well as for future and more extensive operations; and if not enough for *actual power*, to see that sufficient water can be obtained for the requisite steam purposes of pumping, hoisting, crushing, milling, smelting, or other reductions, so as to obtain a substantial and efficient property by security of patented title.

Figure 15.



I have received the particulars and drawings of the above useful machine from my brother, John Phillips, who (having been for many years the local Government's Mineral Surveyor of the Ballarat Gold Fields, then Surveyor and Registrar of Saint Arnaud Districts, and since Principal Teacher of the Government School of Mines, at Ballarat, Australia,) seeing the great necessity for more convenient, economical, and yet efficient, means for preliminary examinations of extensive bodies of auriferous quartz in that country, contrived the compact combination of mortar and pan for simultaneous pulverization and amalgamation, as shown by figure 15, which he calls the "PORTABLE QUARTZ REEF-TESTER."

He has also invented an exceedingly ingenious and skillfully calculated (though less practically useful) gold valuing lever, for ascertaining at sight the quantity of gold contained within any nuggetized stone of quartz, of course when other substances of different specific gravities are absent, which is more frequently the case in the gold fields of Australia than elsewhere.

It records the answers to twelve separate desiderata, and this, too, without the use of any weights, being simply ascertained by equipoise of the test sample with a lesser substance, as governed by the relative specific gravities of the more or less valuable quartz.

The following table will be of frequent service to those industrious prospectors who may prefer working their own veins, and forwarding the various ores to distant markets:

WEIGHT OF A CUBIC FOOT OF THE METALS AND ORES IN POUNDS AVOIRDUPOIS.

	WEIGHT.		WEIGHT.
Gold, native	1250	Iron, native	856.25
Silver, native	723.75	Pyrites	300 00
Copper, native	525	Magnetic	312.05
Pyrites	259.31	Arsenical	381.25
Red	315	Specular	282.25
Gray	266.87	Hematite	225
Malachite	250	Nickel, native	450.25
Tin, oxide	406.25	Arsenical	281.25
Lead, native	706.37	Sulphuret	331.25
Galena	468.75	Uranium (Pitch Blend)	404.65
Carbonate	403.75	Baryta, heavy spar	208.75
Zinc, native	250	Lime Rock	156.25
Oxide	327.05	Calc Spar	156.25
Antimony, native	412.05	Fluor Spar	190.25
Oxide	347.12	Silica (Quartz)	162.05
Cobalt, native	800	Granite	153.25

NOTE.—A vein of ore one inch thick, six feet long, and six feet high, will measure about three cubic feet, and weigh in proportion to the specific gravity of the mineral.

SECTION III.

ASSAYING AND DISCRIMINATION.

CHAPTER I.

SYSTEMATIC PREPARATION OF THE SAMPLE TO OBTAIN AVERAGE EQUALITY FOR DISCRIMINATION OR ASSAY.

To take a sample from a ledge or parcel of ore that shall fairly represent its average, and prepare it so that the lesser quantity weighed for assaying, shall be sufficiently homogeneous for a correct ratio of value, is really the most difficult part of mining, and should be conducted with vigilant care, as this is the important preliminary test for succeeding profit or loss by mining or reduction.

The retrospection of the resultant losses from disregard or ignorance of this subject is exceedingly ridiculous, as it has injured mining so much that many years must elapse before even legitimate properties will be recognized by capitalists. Mills and smelting works should be used for realizing profits from established riches, and not as enormously expensive assaying appliances on slightly tested, doubtful ledges.

In the last chapter of Section II, the prospector had taken a careful average from his ledge, by breaking rock from a thousand places throughout its length and breadth, which, after it had been broken still smaller, to the size of peas, was carefully collected and thoroughly mixed together.

We will now receive this sample from him, and manipulate for an example, in a manner that has neither been described in books nor practiced by assayers, but which you will find better adapted for obtaining correct results than any other method.

The Cornish system of quartering the parcel, (fig. 16), or cutting a gang-way through the center, (fig. 17,) though sufficiently near for concentrated base minerals, will not approach to it in accuracy, for gold and silver; the chief causes of error being the unequal distribution of coarse and fine, or light and heavy, which carry a more or less difference of quality, by taking irregular positions from the center outwards, or from the top to the bottom of the pile, and by lying nearer the perimeter of the quarters, or falling unequally in the gang-way, it gives a less average than it should for the miner, because the least friable pieces, being consequently larger, fall to the bottom of the cut, or to the periphery of the pile, and, being more quartzose, contain less mineral than those parts more readily broken; it is, moreover, less simple than the halving mode (to be described,) doubles the length of the lines of error, and lacks the additional guarantees of the repeated mixings, trailings, and dividings, during its more systematic reduction. The monopolizing and exacting smelters are fully aware of this undervaluing mode, but take all advantages from the unresisting miners.

Fig. 16.

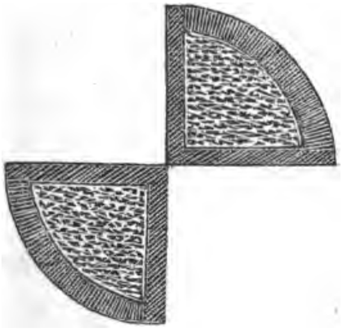
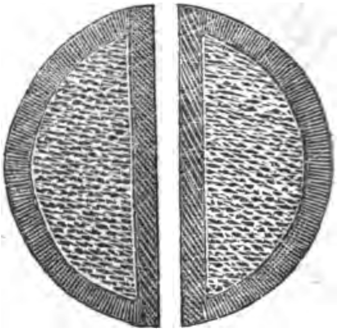


Fig. 17.



If you wish to have a correct average, or expect the certificates from the different assayers to agree, this must be performed faithfully in the following manner:

Spread the partially equalized ore over a clean spot, to the shape of an inverted prospector's pan, draw a diameter line—or, still better, a large sheet of iron or piece of plank—through the center, and remove the whole of one-half, coarse and fine, therefrom, which thoroughly remix by repeatedly turning it over; and then shape and divide as before, until the sample is reduced to ten pounds. Pass the whole of this ten pounds on to a clean newspaper, sheet of glazed paper, prospecting pan, or plate, and again mix as intimately as possible, by alternately *collecting it several times to the center*, and *redistributing it* with the finger, *by trailing a watch-spring path from the middle outwards*, (as shown by fig. 18); again divide this ten pounds by laying some thin, vertical partition, as a handsaw's back, or a table-knife, through its diameter line down to the very bottom of the sample, (as fig. 19,) and sweep, with this knife or saw, and a hare's foot or brush, the whole of the coarse and fine of the nearer half away, as thoroughly clean as possible.

Fig. 18.

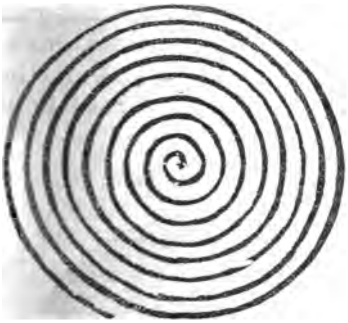
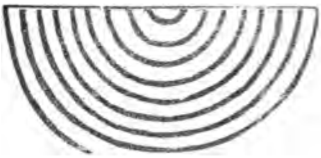


Fig. 19.



Pulverize the remaining five pounds to the maximum size of rice, *without sifting*, and, after mixing, dispersing, and dividing, thrice, as previously described, pulverize and then sift this ten ounces with the finest gauze sieve, such as that supplied with the assaying machine, carefully noting its upper side for flattened disks of the metals gold, silver, copper, etc., which, if found, must be weighed to ascertain their percentages to the whole ten ounces, or any other total quantity, and added to that resulting from one ounce, or other weight taken for assay, from what did pass through the sieve.

In gold and copper assays, this occurs frequently, and sometimes in silver; but, with the latter, a tough metalliferous chloride often flattens into treacherous cakes, which, by not passing through the sieve, vitiates the resultant assay from such an ore, unless guarded against, and then separately valued; which, in the case of silver, must be also smelted and refined. Lastly, invert the sieve on pile, and drop the adhering particles of ore or metal by tapping and rubbing.

If no metal is present, or extreme accuracy is unnecessary, about two and one-half pounds may be taken from many parts of the large heap, instead of the ten pounds, and otherwise treated as directed until it is reduced to such a quantity as you need for the metal sought by the particular method of assay being used.

This last, after sifting it through a fine sieve, must be remixed, distributed and halved as before; and, if the ore is infusible or refractory, this should be further pulverized under the pestle, by rubbing, to an impalpable powder, when, after being again mixed, it is ready for weighing the sample for the assay.

This mixing, after pulverization or sifting, is imperatively necessary, as the pestle as well as the sieve passes the more friable portions first, thus rendering the bottom of the pile richer.

Tapping or jostling, which causes the heavier and richer portions to settle to the bottom, should also be carefully avoided until the sample is weighed.

It will be instantly seen and admitted that this method of cutting off the one-half of such intimately mixed sample, approaches as closely as possible to mathematical accuracy, as there is really no line of error, as the absolute half of a similar pile is thus retained.

It has been the English practice to ascertain the water-weight, by drying a portion at 212°, and taking the assay from the dried sample, or allowing for it by adding as much as will equal it when weighing for the assay; but it has not been done in this country.

Should you require to know this, dry one hundred grains of the ore on a plate, saucer, or some clean vessel, placed, *as a lid*, over a *tea-kettle*, or *coffee-pot*, containing boiling water; and ascertain its percentage of loss on re-weighing the dried residue, by subtraction.

CHAPTER II.

DESCRIPTION AND GENERAL ADVANTAGES OF THE "WEE PET" ASSAYING MACHINE.

The above is the name given to a machine that has been devised for the benefit of the mining public generally, but which is more especially valuable for the prospectors of this great and but partially examined mining country. Beyond the regions that have been and are now being explored, hundreds of primitive mountains, with their tilted declivities of secondary strata, are looming in the distance, to entice forward the more adventurous, where, if the historical analogy of the mining world should be their guide, very many interesting and legitimate fields remain unexplored.

It has been correctly observed by some of the best and most practical authors on mineralogy, that however experienced a miner may be in the visual discrimination of gold and silver ores, he is often deceived in his judgment of the value of rock ; and this applies to ores of much greater value than such as will pay for mining and reduction ; as the mixtures of volcanic regions, and the ores of antimony, copper, lead and iron, wherein precious metals are completely concealed. These authors also commend the common mouth blowpipe as an inseparable companion of those requiring greater certainty in mining operations, for both testing and assaying of minerals, but more particularly for silver, which it performs with surprising accuracy. Its powers are truly wonderful, but proper instruction, great practice, and expensive tools, are imperatively necessary; as well as the peculiar qualifications for handling, manipulating, smelting, and cupelling an assay of but one grain, and where the resulting button is so small that the one-thousandth of a grain would be but $37.70, and the one-ten-thousandth $3.77 per ton of 2000 pounds. I know of no other single chemical operation that requires more knowledge, practice, care and watchfulness, to obtain exact results. These, with many other difficulties, to which there is no "royal road," and the greater need for preparing a correct and homogeneous sample, to render that, of but one grain, the correct representative quality or ratio for the ton, have and will prevent its general application.

The crucible and scorifier require a large furnace and muffle, with numerous tools, etc. They are slower in action, and consume a large quantity of expensive fuel, all of which must be carried from place to place, as required; so it is far worse than the former, as all are thus prohibited from its use.

The humid or chemical methods demand many costly and fragile tools, with dangerous liquids, an especial education, and much general experience and practical knowledge; or they will only be useless encumbrances.

Thus, the explorers have been roaming ignorantly, where knowledge was most desirable, and the legion of mining companies have forwarded mills at a cost of from $20,000 to $100,000, for assaying an average from their ledges, to prove, most ruinously to them, that but *one* in fifty are valuable. Millions of tons have been reduced that would not pay, by either milling or smelting, for want of an easy, preliminary means, to ascertain its value.

In view of the immense demands of this country, and knowing the insufficient methods in use by miners, millers and smelters, *when required for prospecting*, as well as the first and most important difficulties of my students in their manipulations with the common mouth blow-pipe, I have contrived this machine to overcome all the real obstacles pertaining thereto; such as a continuous blast, preparing and fluxing the assay, shaping its holder and charcoal support, cupels, etc., as well as holding and varying its position during the smelting, cupelling and refining operations; and ascertaining by tables, which lie under and on either side of the balanced button, as it rests on the beam, the value in dollars per ton, or its thousandth's fine for silver and gold, and percentage in base metal assays; all being read at sight, without calculation. This weighing is much facilitated by taking the difference of large weights, instead of using the minute weights, riders, etc., of assayers by other methods. In addition to this, I have another patented calculator by two diverging metallic straight-edges, laid on a bed, so that the one end may represent

$200, and the other $1; the intermediate space being graduated from $1 to $200, and wherever the button *jams*, its value is recorded on the scale. There is also a hole at the end of this plate, of such size that a $30 button will just drop through, when the explorer may proceed on his journey for other ledges, as this is not sufficiently rich to pay for mining and milling silver ores in the interior. This applies to samples of ten Troy grains, for silver assays, in dollars per ton.

Another graduated scale lies on the opposite side, for gold assays, from 160 grains or 1600 grains, etc., after water concentration, which for the former ranges from $360 down to $2, and for the latter quantity, from $36 to $1 and cents, per ton.

By these combinations, the apparatus has surpassed my expectations as to the quantity of ore it will reduce. I have operated successfully on twenty grains, although it is arranged for ten grains to the public; it is claimed that with these arrangements and combination of automatic movements and calculator, a man of ordinary skill can make an assay with this apparatus anywhere, even on the ground, sufficiently near for all the practical working purposes of those to whom it is dedicated, and in less time and at one-tenth the cost of any other method. So portable is the apparatus, that the whole machine, with fluxes, tools and scales, (weighing less than seven pounds,) is packed for conveyance within a cubical box of about five inches. The price of the whole is $100, accompanied by a book of instructions for assaying gold, silver, copper and lead. Those buying a machine in the city of San Francisco, having the further advantage of receiving instructions from its inventor and patentee.

The machine is also most conveniently fitted for the general purposes of the laboratory, as shown by the illustrations, as roasting, drying, crucible fusion, and ignition; fusion *per se*, or with an alkaline carbonate, on charcoal; of ten or twenty grains: for testing with tubes, flame, flux re-agents, in forceps, or on wire; and to dry, sublime, evaporate, boil, distil, filter, etc.

For the purpose of fusing very stubborn metals or minerals, it may be rendered very much more effective by introducing separate jets of oxygen and hydrogen, formed when used, and ignited by the ordinary flames, at the moment of exhalation; or a reservoir of alcohol may be placed beyond the assay, which, being warmed by the waste heat from the departing flames, would force its jet of alcoholic vapor through a similarly placed central nozzle, and, by supplying this auxiliary combustible, the heat would also be greatly intensified.

The machine was exhibited in 1869, at the Mechanics' Institute Fair, where it was awarded, by the Examining Committee of Philosophical Instruments, a gold medal, with the following encomium:

> "FIRST PREMIUM GOLD MEDAL TO J. S. PHILLIPS, FOR 'PORTABLE ASSAYING MACHINE.'
>
> "*For convenience in use and accuracy of performance, we esteem this little machine as of the greatest utility to the mining prospector, and well calculated to relieve our mining interests of the uncertainty hitherto attending their developments.*"

The apparatus has been but partially detailed here, as it will be more minutely described in the instructions contained in the chapters for discriminating and assaying the various minerals.

I have several especial inventions for prespectors, besides the "Patented Wee Pet Assayer."

2. The "*Tester*" is a cheap substitute for the "Wee Pet" for roughly assaying gold and silver; it measures the resultant buttons between the diverging straight edges of the patented "*Tablet Button Valuer,*" instead of weighing and balancing.

3. The "*Pocket Laboratory*" contains two balances, a set of decimated weights, with every requisite tool and all the really necessary fluxes, &c., for *testing and assaying* by my "*Blow-pipe System.*"

4. The "*Vest Pocket Blow-pipe.*"

5. The "*Little Wonder,*" or "*Self-Calculating Sample and Button-Weigher,*" for mountain assays, by blow-pipe or otherwise. This is a *surprisingly delicate* weigher.

6. The "Automatic Smelter," "Laboratory," and "Little Wonder," combined in one convenient box — eight inches long by four inches wide, and one and three-quarter inches thick. This is indeed a marvelous combination of convenience and efficiency for mountain purposes of testing and assaying.

Each apparatus will be fully described in its proper place.

CHAPTER III.

NEW METHODS FOR THE EXAMINATION AND ASSAY OF ORES BY WATER-WASHED CONCENTRATIONS; SOMETIMES PERFECTED BY ACID SOLUTIONS OR MERCURY, AND COMPLETED WHEN NECESSARY BY CRUCIBLE, SCORIFIER, MACHINE, OR BLOW-PIPE; BY ROASTING AND SMELTING THE HEAVY RESIDUE WITH FLUXES.

The application of water for the discrimination and assay of minerals and metals, is far more appropriate for the daily requirements of the miner, analyst and assayer, than is generally known; and, when systematized, it may be made a very useful auxiliary in many ways; as it is within reach of all, requiring no other tools than those generally found in mining camps, and but little instruction; yet performing, at a trifling cost, more actual work in less time than any other method, excepting chemical analysis, which must be executed in the laboratory by the educated expert, at considerable expense.

To the blow-pipist and chemist it affords a prompt anterior and posterior means for qualitative-quantitative approximation, selection, separation, or concentration; but more especially for preliminary examination previous to more elaborate treatment.

In experienced hands, many samples that the miner has to work, can be actually assayed more correctly by water than fire; and even ordinary amateurs may realize its full value for many practical purposes; as free gold, and other metals, the auriferous sulphurets of iron and tellurium, oxide of tin, the sulphurets of copper and lead, etc., when they are not associated with other metals or very heavy gangues, of nearly the same weight; others can be assayed by water that cannot be easily assayed by fire, as sulphuret of zinc, sulphuret of antimony, oxide of manganese, iron, etc.

It has, however, three disadvantages, which, in some cases qualify its quantitative usefulness : it cannot be used for silver ores, and for the others it is essential that the operator shall be acquainted with visual discrimination of such when in a powdered state, and that the sample is free from those confused mixtures so frequently found in volcanic regions. When the heavy residue is treated by fluxed fusion with the crucible, machine or blow-pipe, these latter more refractory ores will be fully subdued to the necessary condition for practical purposes.

For such men it will frequently be the most convenient method for both examination and actual assay.

For example: take a hundred grains, or parts, from a complicated pulverized sample, prepared and dried at 212°, as directed in Chapter I, Section III, that contains one or more of the following substances: as free gold, platinum, metallic copper, metallic iron, (from the mortar,) oxide of tin, sulphuret of iron, red oxide of copper, sulphuret of lead, gray sulphuret of copper, yellow sulphuret of copper, sulphuret of zinc, and oxide of iron, associated with their matrices of quartz, clay, feldspar, carbonates of lime and magnesia, etc., or others of similar specific gravity and friability. Take three porcelain dishes, as used by the chemist, or three ordinary enameled soup-basins, tea-saucers, or cups, or a good vanning shovel, prospecting pan—or a small six-inch iron pan of similar shape—a horn spoon, as used in the mills and mines, the Mexican batea, or any suitable and clean vessels that you can obtain or may prefer: place the one hundred grains or parts from the dried sample into either of such, and after laying it in the bottom of a still larger vessel, (as a clean pan,) then cover it with about ten times its volume of water, and stir the whole for five minutes ; after allowing it to remain sufficiently long for the water to thoroughly permeate and, if for chemical purposes, to dissolve the soluble portions from the mass which may be facilitated by warmth, and to then pour or filter this water into one of the other vessels for separate examination by re-agents ; thus easily separating these that are soluble from those that still remain insoluble in water.

It may sometimes be necessary, for your purposes, to ascertain this percentage, by transferring it with a camel-hair brush, after it has been dried at 212°, to the scale pan, for deducting its weight from the original sample of one hundred grains.

This dried residue may be replaced in the concentrator, for ore elaborate treatment, and, after covering it with about hrice its volume of clean water, strongly agitate the vessel y properly applied circular and reciprocal motions, and pour off he water very carefully, during a slower transverse oscillation f the pulp, into a third vessel: pulverize with the pestle, by ubbing the remaining sample in the water, shake and pour as efore, and repeat this process until the lighter and more friable ebris has departed, and the quartz approaches the margin.

This third receptacle will contain most of the light and easily ulverized feldspars, clay, lime, and magnesia, which will soon ettle to the bottom, and, after the water has been poured off, an be examined by means that will be described in a future hapter. The oxide of iron will also pass over in this stage, ndicated by the redness of the water, and which can also be hemically tested; the other more solid forms of iron can now e seen in the residue. The remaining quartz and minerals can e then dried if desirable, at 212°, and weighed for percentage.

For the further treatment of the heavy residuum, unless the perator is already well skilled in the use of the vanning shovel, atea, horn or horn spoon, he had better rely on the slow oscillation of the water, across the side margin of the vessel, and take more time for ridding the minerals from the heavy gangues, whilst adopting the following precautions: Supposing the instrument is a small prospecting pan, porcelain dish, tea-cup, saucer, r soup-bowl, it will be better to have sufficient water in the third ish, that contains the earths (which should be removed, if you would test them separately,) so as to enable the operator to alternately keep the side of the concentrator slightly in or out of the water, during the slow sideling sway of the water over the minerals and escaping quartz; at this stage, great care must be taken in giving the proper angle, so that nothing but gangue shall escape; and, towards the finish, a little direct mechanical means may assist the gangue over, or arrest the more forward minerals, that might otherwise pass away into the third vessel.

This being completed, re-concentrate all the dishes in a similar manner, to obtain any mineral that might have passed over in the washings, so that they may be added to the first concentration, to be also dried and weighed. Now, as the first dried sample of one hundred grains contained no water-weight, the second similarly dried sample will give the percentage of the remaining insoluble portion, and, when taken from the original will leave the percentage of what was soluble in water.

The third dried weighing will give the percentage of quartz, compact feldspar, and minerals; which, being deducted from the second, will represent the lighter and more friable oxide of iron, clay, and carbonates 'of lime and magnesia. The fourth (and last,) taken from the third, equals the quartz, etc., and is the weight and percentage of the metals and ores, which may be still further separated by magnet and forceps, assisted by a lens, into different lots of metals and metallic minerals; after being weighed, the minerals may be also calculated for their metallic contents, by their tabulated ratios.*

If more than one of the metals or metallic minerals are present, a careful and experienced hand, when assisted by the magnet or magnetized knife-blade, and an occasional touch, with a few repetitions from vessel to vessel, if necessary, can often separate each, by causing them to follow successively, as just named in the example; which the amateur, by drying and spreading the heavy and closely concentrated residue over a clean plate, can examine with a magnifying glass, and, if desirable, place them with a forceps into as many different heaps, for quantitative assay as well as qualitative, by merely weighing and calculating their percentages from their equivalent proportions, multiplying each individual weight by the following numbers, and dividing by 100; or, better still, by moving the multiplier's decimal point two figures to the left hand, so as to also divide:

The oxide of tin contains 78.38 per cent. of metal.
The bi-sulphuret of iron contains 46.7 per cent. of metal.
The red oxide of copper contains 88.8 per cent. of metal.
The sulphuret of lead contains 86.55 per cent. of metal.
The gray sulphuret of copper contains 38.42 per cent. of metal.
The yellow sulphuret of copper contains 34.6 per cent. of metal.
The brown sulphuret of zinc contains 66.7 per cent. of metal.

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* When it is necessary to both dry and treat by acids, three porcelain vessels are best of all, as a small cup or saucer, a soup bowl, and a large wash-basin. If only to concentrate and dry, the six-inch prospecting pan is best. For concentration only, the batea, horn
, or almost any light and convenient concaved vessel, will serve for immediate
se.

Thus, promptly concentrating, drying and weighing many of Nature's insoluble precipitations as they are found, instead of decomposing them in the laboratory of the chemist, by difficult, far-fetched, expensive means; but for frequent repetition of the separation and precipitation, to similar compositions.

This is, however, a complicated case by any method, either for analysis or assay, and it seldom happens that the sample contains so many kinds; the object of such an example being to expose the principles of this ever ready and convenient means that the *chemically* uneducated prospector and miner has unconsciously at his fingers' ends, in this exacting, practical test; which will also afford a parallel for the general waste of the large scale, by water-washing and milling treatments.

It also illustrates the general constitution, comparative qualities and quantities of the sample, which the most experienced analyst and assayer would least despise, as it opens a volume of useful hints, to enable him to work it precisely as it should be treated; for, discarding nine-tenths of the time occupied in this case, by hastening through the intermediate stages, he arrives at the end in ten minutes, and may be informed that the gold is not all free, but, being partly imprisoned in sulphuret of iron, demands a preliminary roasting, so that the whole value may be realized. For copper, he sees that metallic nuggets will cause a treacherous, varying result, unless the upper side of the sieve has been well attended to during the sifting of a large quantity, and separately calculated, for addition to the result from mineral assay: he knows, also, that the yellow and gray sulphurets must be roasted, and the first metallic button from such should have an additional refining, or an impure excess of weight will be recorded as copper. It informs him that the fire assay for tin would produce but an unfinished, refractory alloy; and, consequently, the assay must be accomplished by some other method, or those next following:

First, complete the assay of this staniferous metal button, as thus obtained, by chemical analysis.

Secondly, dissolve the one part, of one hundred grains, in three parts of hydro-chloric acid, one part of nitric acid, and one part of water, by gently boiling for about one hour, in some position where the fumes may pass away; pour off this solution which carries the gold, copper, lead, iron, etc., and after washing the oxide of tin (which still remains as before) with water, to assay it by crucible, machine, or blow-pipe, as will be described in proper places, at Chapter XII, Section III.

It is a somewhat singular and most advantageous fact that the sulphurets of lead and antimony are not found with tin, which saves much annoyance; for, being of similar specific gravity, and very fusible, they would be so obstinately associated, that not only water would fail to separate them, but *roasting* could not be more successfully resorted to for *after*-separation by water, as in the case with the sulphuret and arseniuret of iron.

Thirdly, re-pulverize, and further re-concentrate, until nothing remains but the gold, copper, sulphuret of iron, and oxide of tin; pick out the gold and copper, with the forceps; roast the remainder at a red heat ; then pulverize, and re-wash until the water ceases to be colored red, when the oxide of tin, appearing clean, can be reduced by either of the fire methods.

Fourthly, after it has been well roasted at a low red-heat, and treated with hydro-chloric and nitric acids, as explained in the second mode, then wash clean with water, dry this concentrated oxide at 212°, and weigh to calculate its percentage, by multiplying by 78.38, and dividing by 100.

Thus, if the weight of oxide obtained amounted to ten grains, the formula and result will stand thus: $\frac{10x78.38}{100}=7.83$ per cent. metallic tin; or, $10x\,.7838=7.83$.

These, second, third and fourth methods, when properly conducted, are reliable, and millions of pounds sterling have been paid for ores that have been assayed less correctly.

This tin oxide is unaffected by the pestle, water, acids, or *unfluxed* red-hot roasting; and, consequently, the roasting, pulverizations, and washings, greatly facilitate to entirely rid it from all the other minerals with which it is associated, excepting the rare tungstate of iron (wolfram); the injurious effects of which, however, have been controlled in the second and third by acids and fire, as the last can be, by the addition of a few drops of nitric and hydro-chloric acids, towards the latter end of the last water washing, before it is dried for weighing.

For lead, in this sample, he finds no correct fire method for its assay, etc., and therefore chemical means must be resorted to, or the lead may be extracted therefrom with the forceps, and ulated from its percentage of metal, or passed by a fluxed fusion in crucible or on charcoal before the blow-pipe, to the metallic state.

In fact, the whole components of the sample are so exposed that, with a good lens, he can see the variously colored metals and minerals, and ascertain their relative proportions and constitutional natures, as distinctly as he would so many flowers in a garden; and they may be separately examined by the blowpipe, or wet re-agents, for further collateral satisfaction, when deemed necessary.

Gold may also be not only tested, but actually assayed most promptly and correctly, by this mode, either in free condition, or when parted from its heavy residue by acid, dried, and directly weighed; or amalgamated with mercury, and smelted by crucible, scorifier, or machine, into button; as fully described in Chapter VIII, Section III.

The blow-pipe, wonderfully prompt and effective as it undoubtedly is, in the hands of the really experienced man, for discrimation; is often deficient in the quantitative examinations of the more useful metallic minerals worked by the miner, thus so readily performed by this less studied and preëminently practical means; to which the best blow-pipist may oftentimes resort for valuable assistance, both before and after his fire testings.

The microscope has been too much extolled for discriminating purposes, as it is so very expensive that it can only be obtained by the favored few, and they must be previously educated to recognize the *visual features* of all the really *pure samples*, which are but *rare*—as the useful minerals are either *dirty or mixed*—and cannot be thus recognized.

CHAPTER IV.

THE MODES FOR DISCRIMINATION BY ORDINARY BLOW-PIPE, OR ASSAYING MACHINE, ASSISTED AT TIMES BY DRY AND WET TESTS, OF SUCH OF THE METALS, MINERALS AND EARTHS, WITH THEIR VARIOUS COMBINATIONS, THAT SHOULD BE KNOWN BY THE EXPLORER, MINER, MILLER, SMELTER, ASSAYER AND METALLURGIST.

The following methods for ascertaining the presence of the useful minerals were written to assist practical men, with use of comparatively simple means, in recognizing the various kinds, and quantities, when sufficient value is contained in an ore for profitable purposes, rather than for the really delicate analysis; and I have, therefore, deviated, in many ways, from the stereotyped records of books for such men's immediate requirements, in a business for which their education had not been intentionally adapted.

If they have desire, time, opportunity, energy, and perseverance, these rudimentary examples will not deter, but encourage them to prosecute the studies of more unusual elements, in the many elaborately systematic works which have been published in the leading languages since the days of the immortalized Berzelius, and the other enlightened practicals of Sweden, to whom the world has been principally indebted for the prompt and numerous reactions obtained from the useful blow-pipe.

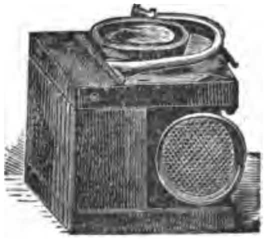
Favoring this system, the assaying machine was contrived for enabling the unpracticed amateur, by auxiliary mechanisms, and general simplifications, to make actual assays of gold, silver, copper, tin, and lead, after a few hours of personal teaching, or by the written instructions contained in this book, and treating ten times as much as the common blow-pipe has ever reduced before. The tools are also present for all kinds of discrimination and lysis, as fusion of ten or twenty grains on unfluxed charcoal, or with an alkaline carbonate, etc.; roasting, sublimation, test-tubing, and ignition; drying, evaporating, boiling, distilling, filtering, etc.; so that such extended studies are hereby encouraged to a remarkable degree.

Naming one or two of such works may be an injustice to others; but the publications of *Harkort, and Muspratt's Plattner's Qualitative and Quantitative, Berzelian Blow-pipe Analysis*, have legitimate claims for originality and completeness; whilst the valuable eclectic text-books of *Elderhorst's Blow-pipe Analysis for the Records of Mineral Reactions*, and *Dana's Manual of Mineralogy, for the Physical Qualities, Compositions, etc., of Minerals*, are well adapted for your general reference.

All of the necessary tools and fluxes, excepting such as are common in mining camps, and the acids and other liquids, (which should be carried in a separate case,) for the following tests and assays, will be supplied with the machine; and the few others that are required by these authors, are described in their works.

The accompanying illustration shows the Portable Prospector's Assaying Machine, when packed for traveling, in a five-inch box.

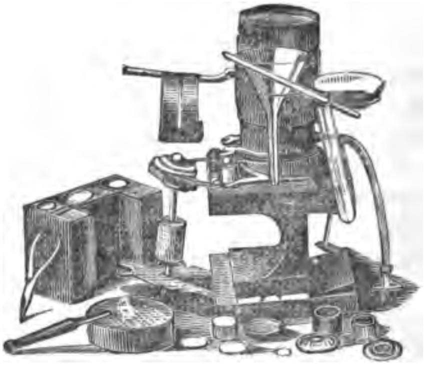
Fig. 20.



In the following discriminations, a few examples will be selected to illustrate the necessary operations for exposing some of the peculiar reactions of the minerals, so as to procure sufficient manipulative skill for the application of the various tests recorded in the alphabetical list of mineral reactions contained in Chapter VII, Section III.

To erect for work, first unscrew the cap or mortar from the top of the machine; remove the flux box and column which are seen on either side; open the tool-boxes around the bed-plate; unclasp the spring-fingers; take off the sieve from this column, and spread all the flux chests, tools and appliances around the apparatus. You will next see, by taking out the bell-cup, that the internal anti-return valve and its joint are air-tight. If these are not in good condition, take out this valve-box, by simply drawing and shaking it from within and gently forcing the rubber tube in from without, sufficiently far that you can lift the valve-box and that part of the tube outside of the body of the machine, for rectification; replace it in a similar manner, by drawing the rubber tube outwardly, and jostling, when the both joints will be simultaneously tightened. Next, place a rubber ring under, and another over, the flange of the inverted bell-cup, and lay it into the stuffing-box, with its long tube down in the opposite corner from the valve; pour water through this tube, into the square chamber of the machine, until it rises just to the bottom of the bell-cup; screw the cylindrical column down on the rubber rings, moderately firm, and stop the blast-holes quite tight, by placing the two conical handles of the nozzles into them; gently blow in by the mouth-piece a full breath, which will raise the water into this column. If the water does not retain its height, there is an air leak somewhere. If it is from the internal square chamber to this column, by way of the rubber joint, it will be evinced by continuous air bubbles arising therein. If the water descends in the column, without bubbling, there is an outward air leak from

Fig. 21.



(Arranged for the general purposes of the Analyst and Assayer.)

the square chamber, most probably by way of the valve or its joint, which will cease after they have been soaked supple by the water; or it may be from around the handles that are in the blastholes, which will be no inconvenience when the machine is in blast, unless the loss is excessive.

If the rubber rings leak water outwardly, they have not been properly placed in position. After this blowing part is ready, and the nozzles do not blow the water through, the wicks can be placed in the four-holed lever, of such a size that they shall just rub in the holes sufficiently tight for keeping their positions, but allowing perfect freedom for the capillary action of the oil, or the flame will not be fully well supplied for the smelting to be performed successfully. This may be seen by the wick being dry, or in active red combustion, instead of serving as the absorbing or carrying channel of oil, for supporting the flame. The trimming of the wick properly is the most difficult part of the operation; it should be so cut that it will be free from stray fibers, run in a parallel diagonal line with the descending blast, and just so large that a well oiled clear flame shall be produced, rather than a too voluminous, ragged-topped or scattered and consequently smoky combustion.

The wick-chamber may now be filled with *olive oil*, when the machine will be in proper order, and like the common mouth blow-pipe, well adapted for the *discrimination of minerals on charcoal*, from their general comportment, as decrepitation, change of appearance, or color of flames; smell of the more volatile oxides or acids from sulphur, arsenic, etc.; fusibility with or without fluxes; comparative dispositions towards reduction to their metallic states; whether magnetic or not, after fusion; change of color; loss of weight from volatilization, or combustion; colors of slags, either alone or with collateral wet tests, etc., as will be explained.

Or for examination in forceps, for some of the preceding, but more particularly for the colors of the flames produced either with or without chemical tests; for comparative fusibility of the more infusible materials; for the change of its color or friability; as well as the characteristically colored lights already explained, and peculiar smells induced by heat.

Or for examination by a small platinum (or iron) wire, crooked into a terminal eye, in which, after certain fluxes are fused, the minerals are added in minute quantities, and again smelted; when many of their elements are readily detected by the color, appearance, and changes, produced by the oxidizing and reducing flames; many of which reactions are wonderfully prompt, delicate, and reliable.

And, lastly, *by open and close-ended test tubes*, in which the pulverized minerals are subjected to the decomposing power of heat, sometimes aided by fluxes, either over a flame from an alcohol lamp, or before that of the blow-pipe across the wick; the more volatile giving off oxides or acids, gases or fumes, that are most readily recognized by sight, smell, etc., etc.

THE OXIDIZING AND REDUCING FLAMES FROM BLOW-PIPE.

To produce positive reactions, it will be necessary to thoroughly understand what governs the result.

In regard to these flames, much has been said and unsaid, both by European and American authors, which has muddled rather than explained this subject, by anomalous contradiction, arising, I think, from their endeavoring to account for their different powers by purely chemical creations before or within the flames themselves, rather than from the mere mechanical positions, that warm, or completely extract by actual combustion, the atmospheric oxygen which is thus driven before blast.

In the following exposition of the flames, those that are forced across the natural flame of the lamp, at a declination of about 10°, before the blast-pipe, are meant, excepting when the original flame is purposely expressed.

Long practical observation leads one to believe that the volatilization, or decomposition and oxidation of a mineral, is produced in an atmosphere that contains *intensely heated oxygen*, which, being thus induced, directed, and pressed, at fifteen pounds per inch, to actual contact with the *hot mineral or metallic fluid*, for which it has *thus acquired* a suitable affinity, and *no other substance* being present, it necessarily *completes its union therewith*, whether the warm air is produced by blue or yellow flames; and, as proved by a furnace muffle, when all other elements, having like affinity, are absent, nothing more than sufficient heat is required to consummate this union; nor is it facili- d or retarded, when exposed, or in the muffle, by color or composition of the outside and distant heat-supplying flames, be they yellow or blue, carmine or green.

The oxidized minerals are also reduced or smelted into metals, when gaseous oxygen is excluded, or attached by some other element having a greater affinity, as hydrogen or carbon, whose local oxidation or combustion, by preventing the entrance of atmospheric oxygen from without and also uniting to that of the enclosed mineral, the metals are produced.

In practice, the whole more cylindrical mass of the flame is more suitable for reductions, because of its amplitude and power; and the small, cone-shaped and clean blue flame, being very hot and finely pointed, is infinitely better for oxidation.

For the general purposes of qualitative and quantitative analysis, these flames have been recommended by Berzelius, Harkort, and Plattner; and the best and most concise description I have seen of them is contained in the rudimentary treatise of Dr. Robert H. Lamborn on the *Metallurgy of Copper*. He says:

"When the point of the blow-pipe is held about one-third the breadth of the wick in the lamp flame, (as in figure 4,) a flame is produced in blowing that is long, slender, and blue; is hottest at the outermost point, (*a*,) and is an oxidizing flame. This action, however, is strongest slightly beyond *a*, (about *d*,) in the stream of heated gas.

"If, now, the point of the blow-pipe be held as in figure 5, somewhat higher than before, and not quite within the flame, a larger and more luminous cone of burning gases may be driven in the direction of *b*, *c*; within the bright portion of the flame at *a*, the above mentioned chemical action on oxides takes place, which causes this to be called the reducing flame."

(The figure alluded to, being unnecessary, is not given.)

For those who will use either a common, or the machine blow-pipe lamp, for discrimination and assay, as directed in this work, these flames may be further described as follows:

The whole flame driven before the blast, when touched by the nozzle at the first end and completely enclosing the sample with fire at the other end, is the reducing or smelting flame.

Oxidation is best effected at one-quarter of an inch beyond a small, and conical, blue flame's terminal point.

Produce these in any manner you may, the first will reduce, and the last will oxidize.

The reducing or smelting flame is obtained *before the machine*, at about where the wick-lever stops after outward traverse.

The oxidizing flame may also be produced at or near the end of the lever's inward ascending limits, which can be transversely perfected, when necessary, by the especially contrived elevating screw that plies beneath the handle of the wick-lever; and if still insufficient, the nearer blast pipes may be slightly moved, to play a little across the other flames.

DISCRIMINATION ON CHARCOAL.

Cut a piece of sound and well burnt pine charcoal, by first sawing it vertically as the tree grew, or lengthwise with the branch, as planks of lumber, to about three-fourths of an inch in thickness, and not less than two inches square; on one of its flat or largest sides, drill with a knife a small recess of the size and shape of a split pea, near to either edge, into which put a piece, no larger than a grain of wheat, of the mineral for examination; or, if the sample decrepitates and a powder must be tested, the same quantity may be moistened with water into a paste, and then pressed well down into a similar concavity, so that the blast shall not scatter it from the coal.

For machine *tests*, light just one lamp, and use the nearest blast-pipe only, by placing the handle of the third and fourth twin pipes into the large main supply pipe, and your small clearing needle into the second orifice.

After the lamp has burned for a minute, trim off any stray fibers, collect the wick into snug shape, and in proper position before the nozzle, so that, when the blast is applied, by blowing a full breath into the machine occasionally, a voluminous yellow or conical blue flame can be produced at pleasure, (by the appropriate motions of the wick-lever and its transverse screw,) for reduction and oxidation.

It will be imperatively essential for accuracy that the charcoal should be first tested by the flames before any mineral is placed thereon, so as to be aware of the natural effects produced; as some coals acquire a coating or coloring from their innate or accidental impurities, which too closely resemble some of the metallic oxides.

EXAMINATION OF THE VEIN STONES, OR MINERAL MATRICES, ON UNFLUXED CHARCOAL: AS QUARTZ, HEAVY SPAR, FLUOR SPAR; CALC SPAR, OR THE OTHER CARBONATES OF LIME; GYPSUM, MAGNESIA, AND ALUMINA; WHEN SEPARATED FROM METALS AND OTHER MINERALS.

A fragment of matrix or gangue stone from a vein or mineralized pocket, being placed in a small recess of the charcoal, it must be held, for about one minute, before the oxidizing flame, during which, if it is not pulverized, you will notice whether it decrepitates, (or suddenly bursts with a crackling noise into fragments,) as fluor spar, (fluate of lime,) and heavy spar, (sulphate of baryta;) if it changes color, as gypsum, (sulphate of lime,) which immediately becomes white, and crumbles into plaster-paris; or whitens, and becomes opaque, and luminous on the edges, in the flame, as calcareous spars; or phosphorescent blue, at a moderate heat, even after leaving the fire, as fluor spar; or partially or entirely fusible, as heavy spar, fluor spar, and gypsum, under long-continued intense heat; or infusible, as quartz, the aluminous earths, and the carbonates of lime and magnesia.

Both lime and magnesia show very bright edges, when subjected to a high degree of heat before the blow-pipe; but the limestones will crumble and slack in water afterwards, and those of magnesia will not.

ADDITIONAL COLLATERAL TESTS, BY CARBONATE OF SODA, WATER, SULPHURIC ACID, AND NITRATE OF COBALT SOLUTION, ON THESE VEIN AND POCKET STONES.

First, add a drop or two of nitrate of cobalt to the heated stone or powder, then re-apply the flame for a few seconds and observe, after it becomes cold, if any change of color has been produced. If brownish pink or flesh-colored, magnesium is present in some of its compounds; if pale blue, aluminum, the chief component of clay. When magnesia and alumina are both present in a pulverized sample, their characteristic colors can be more readily and positively recognized through a magnifying glass. These reactions or changes, thus produced, are very characteristic, as nothing can conflict therewith in practice, unless borax and manganese, or borax and nickel, are also present, which would form somewhat similar beads to that from nitrate of cobalt and magnesia;

while borax would also form a blue with the cobalt from this solution.

Quartz may be distinguished from heavy spar by hardness, not losing weight under fire, fusibility with carbonate of soda on charcoal, and not giving the sulphur reaction by coloring silver brown or black if placed thereon after this fusion with carbonate of soda, when moistened with water.

Fluor spar can be most easily recognized before a flame, or by throwing a stone into a fire, where it violently decrepitates, and each scattered fragment will exhibit a very peculiar phosphorescent light for some time after it has left the fire, which resembles nothing else, and, once seen, will never be forgotten. This stone is composed of fluoric acid and lime, and, when decomposed by warm sulphuric acid in a *glass* vessel, the released fluoric acid (having a strong affinity for silica) immediately attacks the glass, and produces a frosted or etched appearance by destroying its polished surface. This may be performed on a smaller scale upon charcoal, by moistening the sample with sulphuric acid, and treating it beyond the point of a clean flame, so that the *escaping fluoric acid may impinge* on the glass.

The other lime-stones may generally be known, after having been well burned, by their slacking in water, similar to the commercial article; the carbonates, also, by their somewhat violent effervescence in all of the strong acids; and gypsum, the sulphate of lime, may be tried by the additional test already given, of fusing the sample with carbonate of soda upon charcoal, which then, by producing a sulphate of soda, that is soluble in water, it colors the silver from brown to black, according to the quantity present, or time allowed for the reaction. This test becomes much more prompt and delicate, when the silver coin that supports the sulphate solution is slightly warmed over a lamp.

Figure 22.

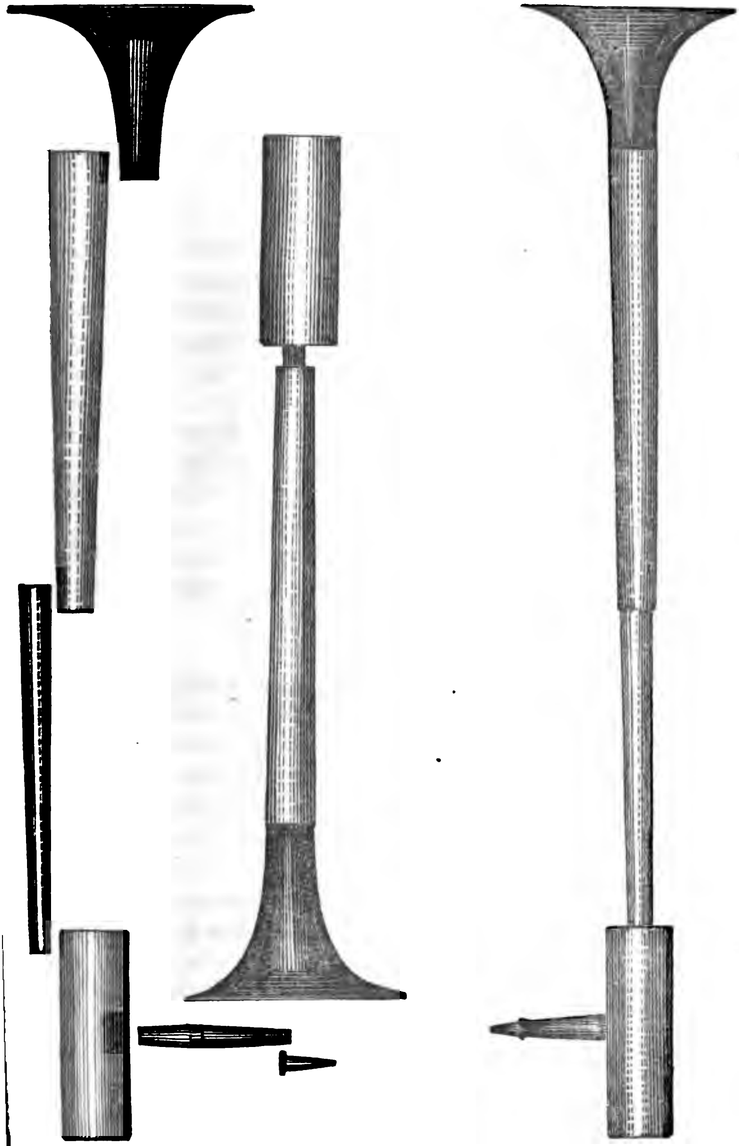
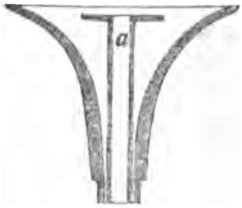


Figure 22 represents a telescopically arranged Berzelian blow-pipe, that may be carried in the vest pocket, which I have cut after the manner shown by the triple illustrations; as fixed for use, separated, and packed for traveling; which are sufficiently explained by the cuts.

The ordinary form, though most convenient and exceedingly small for laboratory uses, is untowardly long for the prospector's pocket, and general itinerant purposes.

In a section of a portion of this blow-pipe, (fig. 23,) *will be seen, within the mouth-piece, another peculiarity — the small inserted flanged tube, marked a; which most effectually stops the water that would otherwise pass from the mouth into the blow-pipe and over the charcoal, during long blowing for the various quantitative results.*

Figure 23.



Its action is most complete, as the water cannot turn the corner of the flange. It can be easily applied to any bell-mouthed blow-pipe, and as it is always better and less tiresome to receive the bell within the mouth, *to be pressed by the blast against the interior of the lips*, than to *press it mechanically against their exterior*, no inconvenience can arise from its presence.

EXAMINATION OF THE MORE USEFUL METALLIC MINERALS, BY SMELTING WITH FLUXES ON CHARCOAL, SOMETIMES ASSISTED BY WET TESTS.

Take, for an example, about one grain of the pulverized sample, prepared in the manner described in Section III, Chapter III, page 164, and, after mixing it in the mortar with its bulk of carbonate of soda, pulverize it with a little water into an impalpable paste, and place it in a cylindrical cavity about three-eighths of an inch in diameter and three-eighths of an inch deep, formed near one edge, on the flat side of the coal. Blow a very gentle oxidizing flame thereon for about one minute, and then the whole of the reducing flame, which must completely cover the sample, for two minutes; and, lastly, the oxidizing flame, with the test about three-eighths of an inch beyond its blue conical point, for about a minute longer, when you may cease blowing, and carefully examine the appearance of the charcoal, both when hot and when cold.

At some distance from the cavity that contained the sample may be seen, whilst it is still hot, the orange-yellow oxide of lead, which will become sulphur-yellow when it is cold. The oxide of zinc is yellow when hot, but *white when cold;* and, if the oxide of lead is also present, the yellow becomes *narrower when cold.* Close to the assay will appear the heavier white oxide of tin, which is slower in deposition, and after it has been moistened by one drop of the nitrate of cobalt solution, and fused before the oxidizing flame for about a half-minute, it will show, when it becomes quite cold, a change to the characteristic color for tin, of greenish blue; and, further from the assay, the green of zinc. With the assistance of a powerful lens, you may also see the clear *pale blue* of alumina, and the flesh color of magnesia in patches of the variously composed and scattered slag.

Now, by moistening the mass with hydro-chloric (muriatic) acid, and reflaming, the first flame produced thereby will be blue, and then, after a few seconds, the green flame from copper will appear.

Next, lift the whole slag from the charcoal, and apply it to the magnetic needle of your compass, (which should have a removable glass for this purpose); it will be magnetic from reduced iron, or iron from the mortar, which latter might have been prevented by bruising in brass or between stones.

Lastly, the presence of sulphur may be recognized by laying the sulphate of soda, thus already formed, upon wet silver, as in the previous examples.

This is a complicated case, and, as regards the earths, the colors are too much mingled by fluxed fusion, and obscured by metallic oxides, for reliance thereon; but it serves as an important illustration of the preliminary water separation, as described in Section III, Chapter III, and as an example for the less intricate cases in the alphabetical list of mineral tests recorded in Chapter VII, Section III.

EXAMINATION IN FORCEPS.

The platinum-pointed forceps are most appropriate for this work, as they resist all single acids as well as the ordinary fire; but a small iron wire may be turned round to form natural spring-points for many occasional purposes, as it bears to some extent the heat from the blow-pipe, does not color the flame with the reagents that are used, and if the test is saturated with the acid, when off from the wire, it will serve for some considerable time, in the absence of the superior article.

The forceps are used for holding small pieces of minerals between their spring-points, in the flame, without fluxes, but occasionally with an acid; and it is best adapted for observing the changes produced by heat alone, as decrepitation, luminosity, and color; the fusibility of the more infusible earths, the colors of the flames or effects generated by such heat, or when aided by some wet solvent; as well as for magnetic action and the characteristic odors that may be evolved.

To apply this test, just take a small, sharp-edged, piece of the mineral, about the size of a pin's head, between the self-closing spring points of the forceps, and after it has been acted on by a clear strong flame for a few seconds, to notice if it decrepitates, changes color, or becomes lustrous, or fuses entirely, but partially on the sharp edges, or not at all; if the flame shows any peculiar color, either before or after the mineral has been moistened by a characteristic solvent, as that of hydro-chloric acid for copper, which, after first giving a blue, from chlorine, concludes with the green from copper; if it is magnetic either before or after long-continued blowing; and, lastly, if it will slack like lime, in water.

DISCRIMINATION BY FLUXES IN THE PLATINUM WIRE LOOP.

This method for qualitative analysis, so portable and convenient for use, is as wonderfully prompt in action, as beautiful and infatuating in its incontrovertible and astounding results; only requiring but a mere speck of the mineral, it acquires more information in a minute, as regards its more palpable reactions, than other means by several hours; and this so easily, that it is in such cases invaluable for the mineralogist, metallurgist, and general chemist, in dealing with many natural minerals and metals, as well as chemical precipitates; the more so because many of them are the most difficult by other known wet tests.

The miner and metallurgist will realize those of the following examples in his practical avocation:

For illustration, a sample that becomes magnetic after complete fusion on charcoal, from the presence and partial reduction of iron and nickel, may be pulverized, then well washed with water, and examined thus: Take a piece of small platinum wire, (of the size of the smallest bird-cage wire,) which may be from one to three inches long, and fix it in a metallic or wooden handle, as you would a brad-awl; next turn the outer end into a very small hook, like a shepherd's crook, or as an eye, of about the size and shape of the note called minim in musical notation; hold this terminal loop or eye into the clean oxidizing flame until it becomes red hot, then dip it into some pure borax or *borax glass*, (borax previously fused in a crucible to expel its water of crystallization,) and warm it in the flame until it fuses to a colorless liquid, which cool and moisten with water if the sample to be tested is dry, so that a small portion may adhere thereto, or dip it into the ore if it is wet, as the above water-washed concentrated sample, or as a chemical precipitant would generally be. Now, if the magnetic mineral contains any iron, the bead will be changed by the oxidizing flame to red whilst hot, and yellow when cold, but in the reducing flame to bottle-green; and when a particle of metallic tin is added thereto, this color is increased to copperas green.

If the magnetic mineral is cobalt, it will produce a bright blue bead, in both flames, when hot and cold.

If the magnetic mineral is nickel, it will be violet when hot, and reddish brown when cold, in the oxidizing flame; and, after long-continued heat, in the reduction flame, it becomes colorless. For more positive proof of the presence of nickel, the absence of manganese must be demonstrated, which gives a somewhat similar bead, and, being frequently associated with iron that also attracts the magnet, it would, by too closely resembling nickel, lead to error. The presence of manganese may be most readily ascertained by thoroughly cleaning the platinum wire from borax, and testing in similar manner with a clean bead of carbonate of soda; if manganese is present, the glass will fuse to a very characteristic green, which becomes bluish green when quite cold; whilst the nickel would be reduced in this flux to the metallic state; and if smelted with carbonate of soda on charcoal, then pulverized, and water-washed, as described in the latter part of this chapter, the metallic nickel may be extracted with the magnet, from the liquid, or its dried residue, and reëxamined by borax. The manganese and cobalt cannot be thus reduced, and the iron is known by the differently colored bead.

The characteristic colors of the fluxed mineral beads, when some of the metals are in excess, can be much more easily performed and distinctly recognized after pulverization than by the impracticable method of flattening the hot slag between forceps, as described by many authors.

The above example should serve to show the importance of keeping the fluxes separate, and obtaining them chemically pure, as otherwise much useless confusion will result.

Another application of this method of testing will suffice both for colors of beads and flames:

Prepare a clear bead, in a similar manner, with microcosmic salt, (the double phosphate of soda and ammonia,) which fuse with oxide of copper to saturation, or with mineral copper oxidized with this re-agent of microcosmic salt, before the point of the small conical blue flame, until it shows the strong characteristic colors of green when hot, and blue when cold; next add thereto any substance to be tested for chlorine, as hydro-chloric acid, chlorides of sodium or ammonium, chlorides of zinc, silver, or copper, chlorides of calcium, barium, etc., etc. If chlorine is present in any form, a beautiful blue flame will be produced for a short time, immediately beyond the point of the oxidizing flame and sample, in the ignited gases as they are driven before blast; and, if hydro-chloric acid is being tested, as it is also a solvent of copper, after the chlorine flame passes away, the characteristic green flame of copper will appear; and, when chloride of sodium is examined, that of the strong yellow flame produced by soda will predominate, the blue from chlorine showing on the borders during the first few seconds only, whilst the soda will continue visible for some minutes.

This test for copper may, however, be more easily applied in the platinum forceps, by moistening the unfluxed solid with hydro-chloric acid, and placing it in the heated current produced beyond the terminal point of the oxidizing flame.

DISCRIMINATION IN CLOSE GLASS TUBES, OVER THE CLEAN FLAME OF AN ALCOHOL LAMP.

To form a tube-stand with the machine, place the cylindrical roasting furnace on the pressure column, and screw on the short double-jointed lever thereto, as seen in figure 21, page 172; attach to its outer end the three-holed tube-holder, and insert a close-ended test tube in one of these holes, so that it shall have an angle of about 25° from the horizontal. If you have no alcohol lamp, take a common conical ink bottle, and drill a hole in its cork sufficiently large to receive, *loosely*, an empty cartridge from a small pocket pistol, and then to stamp or drill, with the point of a knife or scissors, a one-fourth inch hole in it to receive a suitably sized cotton wick.

To operate on a mineral sample supposed to contain mercury, which, being very volatile, will require this close treatment; you may first mix about one grain of the ore with its weight of dry carbonate of soda, then place it in this tube of about five-eighths of an inch in diameter and closed at the one end, so as to gradually apply the heat of the lamp beneath, for about ten minutes. If mercurial ore is present, it will be decomposed, and its volatilized metal will condense and settle in the upper and colder part of the tube, which can be more easibly recognized by a lens when the condensed metal is collected into ridges and globules, by rubbing the internal surface of the tube with a glass or clean metallic rod.

A still more delicate test is that of inserting a piece of copper, or gold leaf wrapped around a small iron wire, into the tube to about a half-inch above the heated sample, as suspended in position by a suitable crook at the upper end; when, if the smallest quantity is present, it will whiten gold, brass, copper, etc., by amalgamation. (See Chapters VI and VII for test on coin.)

DISCRIMINATION IN GLASS TUBES OPEN AT BOTH ENDS.

These tubes should be about one-third of an inch in internal diameter, and may be passed loosely into one of the holes of this three-holed lever, in such a manner that it shall rest securely therein, when dipping at an angle of from 20° to 30° from horizontal; the mineral to be examined must be pulverized, and should lie within about three-fourths of an inch from the lower end of the tube; the natural flame from an alcohol lamp will be generally sufficient, but sometimes, when greater heat is desirable, the blow-pipe may be used to play increased heat of the flame beneath where the sample lies, when the most stable minerals may be decomposed, and their volatile elements carried upwards by the rarified gases, to either settle in the colder parts of the tube, with characteristic colors at their respective distances, or, pass through the upper end into the air, to be detected by peculiar smells, acid properties, etc., etc., as well as from all these peculiarities, when connected with the tests by other methods; as antimony from its flowery perfume, arsenic by its disagreeable garlic stink, and both by their white volatile oxides, in the tube and the smoke passing through; sulphur by its yellow and yellowish-white oxide within the tube, and odor of sulphurous acid. (See Chapters VI and VII for Mineral Reactions.)

These samples will be sufficient for exposing the methods of manipulation, which may be further extended to suit the tabular records of mineral reactions, published in technical books.

EXAMINATION BY SMELTING AND WATER-WASHING.

For qualitative-quantitative information, to ascertain if any, or which of the smelting minerals may be in a stone, it is often very efficacious to fuse a quantity, say one grain of the pulverized sample, with the ordinary blow-pipe, or ten grains before the machine, as follows: First, mix with the mineral equal volumes of carbonate of soda, borax glass, and cyanide of potassium, and after it has been placed in a paper cartridge, and fused by the reduction flame for ten minutes, many minerals, if present, will be reduced to metals or alloys. Next crush it to a fine powder, without sifting, and wash with water, as described in the chapter on water treatment, which will pass away the soluble and lighter débris; then pulverize, by rubbing the wet remainder under the pestle, and re-wash to pass off all but the flattened metallic disks, which for practical purposes may be fully examined with the naked eye; but when vision is assisted by a magnifying glass, the most minute quantities can be thus detected, after this flattening and brightening, if the manipulations have been carefully conducted; and the metals, when not alloyed, can be promptly recognized by their colors, etc.

CHAPTER V.

TESTING THE USEFUL AND PROFITABLE MINERALS, BY A NEW METHOD FOR PRACTICAL MEN.

These modes for examination are intended for men having no other tools than those found in and around all prospectors' and miners' camps.

EXAMINATION OF THE VEIN-STONE MATRICES.

In the examination of a stone that has been broken from a mineralized vein or pocket, (which is in itself a safeguard for the absence of many other stones and earths, and confines the number to but a few for discrimination,) first observe its color, hardness, crystallization, and weight, or specific gravity, by handling, or actual weighing, etc.

If it is white, and more or less transparent; rosy or rusty white; *scratches glass*, and is wholly or partially composed of *six-sided pyramidal crystals*, that terminate in abruptly *mitred points*, from the same number of sides, either at the one or both ends, and does not decrepitate, (burst with a crackling noise,) or lose weight after being roasted for half an hour at red heat; or change in any other way, and still bruises with difficulty to a fine powder; it is quartz.

If the test-stone is water-white, yellowish, sky-blue, greenish-blue, rosy red, amethystine, purple, deep purple approaching to black, very brittle, does not scratch glass, and is not scratched by the nail, is of a *cubical* crystallization, and on being heated in the fire, in a comparatively dark place, it *suddenly bursts with a crackling noise*, and scatters into numerous pieces, exhibiting *peculiar phosphorescent lights*, which vary in color just as much as the mineral itself, and *continue visible for some time after they have escaped from the fire;* it is fluor spar.

If the stone is white, rusty white, yellow, greenish or grayish-blue, *too soft* to scratch glass, and *does not decrepitate* if placed in a hot fire, but becomes *lustrous when very hot*, at the *latter stag* of an hour's roasting, and white when quite cold, having los some of its weight, acquired a *caustic taste* and *slacks or crumbles* like commercial lime, *in water;* it is one of the carbonates o lime, as compact marble, which looks somewhat like loaf sugar; or chalk, that readily marks whatever it touches; or blue limestone; or calc spar, which is fine-grained, wax-like, soft to the touch, and is easily scratched by the nail.

These and other carbonates effervesce in all of the strong acids, which is good collateral evidence; but crystallization shows nothing for your purpose in this example, as more than eight hundred modifications from the obtuse rhomboid have been observed.

If the stone is dirty white, yellow, red, brown, or gray; of a horny or pearl-like appearance; or bruises to a flour-white, or is easily scratched by the nail to this flour-white appearance; it cuts into thin, flexible flakes, and immediately whitens and crumbles in the fire, during visible curvilinear motions, as if suffering pain, and speedily becomes caustic, with loss of a considerable ratio of its weight, and slacks in water; it is gypsum, (hydrated sulphate of lime.) As an additional proof, the sulphur may be detected by fusing some of the pulverized stone with carbonate of soda, (or saleratus, which contains it,) in an iron spoon, over the fire, and placing a piece of the slag on a silver coin moistened with water, when, if sulphur is present in any form, the silver will be tarnished to brown or brownish-black, from the soluble sulphate of soda thus formed. This may be facilitated and intensified by placing the coin over a clear lamp flame, or upon a previously warmed stone, baking-dish, or other hot substance.

If the rock is white or sometimes dirty yellow, bluish, or from red to brown on the faces, and bruises whiter; is very heavy to handle and of a glass-like spar appearance, but will not scratch glass; decrepitates in the fire with luminosity or phosphorescence; lessens its weight by ignition, but does not slack in water; and gives the sulphur reaction on silver, as described in the preceding test for the sulphur of gypsum: it is sulphate of baryta, or heavy spar. The metallic mineral carbonate of iron is sometimes white, but is unusual, and may be discovered by roasting in a hot fire with charcoal, after which it becomes magnetic, bruises red, and washes away in its colored water.

This may be varied to suit certain cases, as occasion may sugest; and it has been shown that the sage-bush fire had no effect n quartz, which scratches glass; these, with crystallization, and his heat test are all-sufficient detectives for fluor spar, by exposng its properties of bursting into luminous phosphorescent paricles: as fire is for carbonate of lime, which is thus made to slack n water; and for gypsum, by causing it to crumble almost immeliately into "plaster of paris" powder; whilst the heavy spar s distinguished from quartz, the carbonates of lime, and from ypsum, by decrepitation; and from fluor spar, by lacking its ery characteristic long-continued phosphorescent light.

The fusion with carbonate of soda in the iron spoon will prove, f it is white lead ore, by smelting it to metallic lead, as well as he presence or absence of the *sulphates* of lime or baryta, which an be further distinguished by either *whitening* or *decrepitating* under the action of the fire.

If you have acids, they will prove the carbonates by effervescence, and quartz or gypsum by their insolubility.

SEPARATE DISCRIMINATION OF ANTIMONY, ARSENIC AND SULPHUR, WHEN IN COMBINATION.

Cast a stone of the mineral into a hot fire; if antimony is present in practical quantity, it will soon fuse into a waxy slag, which then, burning bluish green, vaporizes off in copious white fumes, which have a slight flower-like odor; and if a rod of iron be placed therein, it will obtain a white coat from the condensed oxide of this metal.

If arsenic is present, a portion of it will volatilize at a moderate temperature, and the remainder at a still higher degree of heat, its white oxide condensing upon the cold iron as that of antimony; but it does not fuse to a slag, and emits an offensive garlic stink that can be easily recognized. The water-washed ore of antimony has also a decidedly different appearance from those which contain arsenic.

Sulphur is known by its oxide being less voluminous and somewhat yellow, but more decidedly by its stubborn, slow departure, and peculiar, sulphurous smell. An admirable and extremely delicate test is that already described for the gypsum and baryta sulphates, but *more particularly when still further enhanced by the warmed coin.*

SEPARATE EXAMINATION FOR THE PRESENCE, QUALITY, AND PERCENTAGE OF THE COMBUSTIBLE ELEMENTS OF THE DIFFERENT COALS.

A very light, natural substance, that is brown or black, and resembles coal, may be placed in an iron spoon, crucible, or other suitable vessel, within a clear fire; if it ignites into flame, and on being removed from the fire, continues to burn for some time, it is coal; and its quality may be estimated from the intensity and duration of the combustion, with comparative weight of the unconsumed residue of stone, clinker, or ashes. If this residue can be blown out of the spoon with a light and natural outward breath from the lungs, it may be safely pronounced a good commercial article, at least for the kitchen or parlor, if not for the steam engine.

If you have a balance and a set of decimal weights, or even the machine, with its calculating balance, by first weighing one hundred grains of coal, then burning it thoroughly and carefully in the spoon, and weighing its incombustible residue, you will obtain by this percentage, its comparative value as a fuel: or, having an assaying machine's calculating lever, you may ignite in a small crucible, placed in the roasting furnace, either one or ten balancings, for a sample, with the weight marked B in the pan, and read the percentage of the residue under where it lies, when balanced with either of the weights marked X 4, or X 3, by taking off one or two figures from the right-hand side of the columns, as the one or ten weighings have been used for the assay, as fully described in the gold and silver bullion, and base metal assays.

GENERAL EXAMINATIONS FOR ALL OF THE USEFUL AND PROFITABLE MINERALS, TO ASCERTAIN THEIR PRESENCE, AND APPROXIMATE PER CENTAGES OF METALS.

To illustrate this system, we will take from a dried sample of pulverized mineral, prepared between two hard stones, or in a brass mortar, as described in Chapter III, Section III, which is supposed to contain any one, or the whole of the minerals and metals of antimony, cobalt, copper, gold, iron, lead, manganese, mercury, nickel, platinum, silver, tin and zinc; take therefrom about a table-spoonful, or, if you have a correct weighing apparatus with decimated weights, exactly one hundred grains, which, after any magnetic iron ore that it may contain has been extracted by a magnet, compass-needle, or a magnetized knife-blade, and placed in a heap on a clean plate for future reference, it must be further concentrated with water in two or three vessels, as fully described in Chapter III, Section III; and then, when the dried metallic residue of gold, platinum, and copper, have been placed in separate heaps on the plate that contains the magnetic iron, the remaining concentrated minerals, which had been passed over into one of the other basins, should be drained of water, and the residue dried at about 212°, by simply placing this basin, as a lid, over a tea-kettle, sauce-pan, or coffee-pot, containing boiling water, until the mineral is completely dried. Next sweep it with a rabbit's foot, rat's tail, a soft feather, or camel's-hair brush, from this vessel on to a perfectly dry and clean plate; scatter the particles, so as to examine their physical characters, and transfer them with a forceps into as many separate heaps, to ascertain their percentages, by actually weighing each mineral, and calculating its ratio of metal, as described in Chapter III, Section III, for the water assay.

The minerals, thus separated from magnetic iron ore by the magnet, when concentrated, dried, and each kind of metal and mineral placed in separate heaps on a clean plate, may be further recognized either by the eye alone, or, with the assistance of a good and clear magnifying glass, as follows:

One portion, sulphuret of antimony, is grayish white, having considerable graphite-like lustre, showing irregular, flaky, divergent crystallizations; which, however, can generally be seen much better before the stone has been pulverized.

Another contains lead, as galena, which is lead-colored, of cubical crystallization, more granular, straight-faced, and less disposed to become impalpable under the pestle.

These are often mechanically mixed together, and may be further examined and approximately separated by fire, thus:

Roast a small quantity, say ten grains, or, if with calculating balance, by B weight, in a clean iron spoon, over a clear fire, or lamp, stirring the whole time with a small rod of wood or iron, and not exceeding black heat during the first ten minutes of the operation.

If sulphuret of antimony is present, white fumes will arise during this period, even at such heat, which will not smell of garlic although it will coat the rim of the spoon or a piece of cold meta with its white oxide, when held in the fumes.

Next, pulverize a small piece of charcoal, and, after adding half-spoonful to the mineral, roast and stir for another ten minutes at a heat not exceeding a low red; remove it from the fire and, when it is quite cold, intimately mix it with its weight o sugar, and about four times as much carbonate of soda, and the smelt this mixture at the greatest heat obtainable in a commo fire, the sample being also covered by a few pieces of charcoal, fo about twenty minutes.

If lead is present, it will be reduced to this well known metal; its purity can be ascertained by its flattening to a thin disk without fracturing the far-extended edges, and by its toughness whe repeatedly bent across its middle.

If still alloyed with antimony, it will break under such treatment, and it must be again subjected to the moderate heat of the fire for periods of about ten minutes, until it stands this test, when it can be weighed for metallic lead; and, by also deducting this from the original weight of ore, the quantity of sulphuret of antimony remains; which, being multiplied by 73 and divided by 100, will give the amount of metallic antimony contained in the ore. Sulphuret of antimony can be fused in the natural flame of a candle or lamp to a black slag, whilst galena is thus infusible.

If one only of these minerals is present, it will not be necessary to smelt it, but it can be weighed and calculated for metallic antimony as above, or by more directly multiplying it by the decimal .73, and for lead from its sulphuret, by—.865.

It seldom occurs that the (white to yellow and brown) carbonate of lead (specific gravity, 6.47) accompanies the sulphurets of these minerals; but when it does, it may be distinctly seen on the top of the (somewhat similar specific gravities) lead and antimony, after concentration by water, and may be known by its color; this must be entirely passed away before the lead-colored residues of sulphuret of lead and antimony are separated by fire, as nothing but grey sulphurets should be present.

The fourth pile may be blue, and, if in quantity, will most probably be the blue carbonate of copper. It may, however, be some of the other very rare minerals, found in small quantities, that also exhibit this color, and must be tested for copper, as will soon be explained.

The fifth pile is green, and is most likely to be, more particularly when generally disseminated within a ledge and above the water-line, either green carbonate or silicate of copper; the former may be distinguished from the latter by friability, wax-like green, smoothness under the pestle, and by effervescing furiously and completely dissolving in nitric acid; the latter has a less waxy, paler green, and more flinty surface, is much rougher under the pestle, and but partially dissolves in this acid, leaving a silicious residue.

As some other rare minerals are green, for absolute certainty, these must also be especially tested for copper.

The sixth pile is composed of one or more of the ores varying from a metallic-lustred steel-gray to a dull and somewhat earthy dark gray or black, and may be gray sulphuret of copper; an argentiferous copper; an argentiferous, antimonial copper; a ferruginous, antimonial, argentiferous copper; an antimonial sulphuret of silver; the gray sulphuret of silver; the black sulphuret of silver; or the black oxide of copper.

The seventh pile is from red to reddish brown; as the arsenical cobalt (cobalt ochre); arsenical nickel (copper nickel); the red oxide of copper (the oxide of iron will have passed away in mechanical suspension, as thick red water); sulphuret of mercury (cinnabar) which bruises to carmine red; the light and dark red silver ores (ruby silver); or the sulphuret of zinc, which bruises and scratches red.

The eighth pile, that was taken from, or near to, the head of the washings, will vary in color and appearance from the lightest to the darkest resin, as some of the iron ores; tin oxide (its only profitable ore), which passes through all the shades of this well known substance; tungstate of iron (or wolfram), its most persistent but worthless companion, which closely resembles the dark specimens of tin ore; its tenacity and specific gravity are too similar for separation by water, as it cannot be thus expelled, even after previous roasting and oxidation so that the oxide of iron may pass away as an impalpable powder mechanically suspended in the water in the manner of the other ores of iron, but it must be dissolved and separated, by acid treatment, after the rest of the minerals have been washed away in water.

Apart from crystallization and specific gravity, garnet closely resembles tin stone, as do some of the irons, manganese, and one variety of hornblende; but, excepting the preceding very rare instance of "wolfram," tin can be recognized and isolated from the others, in a few minutes by roasting and water concentrations. In the pulverized condition, the garnet (which it most resembles) had passed entirely away with hornblende in the water; the manganese occupied a lower position; and the other iron ores may be removed by roasting, fine crushing, and a repetition of the water process, when the redness of the water will expose the presence of oxidized iron.

The ninth pile will be those earthy, friable minerals, without any resinous or metallic lustre, which range from white, through all the shades of greenish yellow, to rusty brown; such as the oxide of lead, carbonate of lead, carbonate of iron, and the carbonate and silicate of zinc.

The first and second of these may be reduced with carbonate of soda, in the iron spoon, or on a piece of charcoal placed in the fire; the third changes color in a hot fire, and after some time becomes magnetic; the fourth and fifth, carbonates, effervesce, and are completely dissolved in muriatic acid; the silicate does not effervesce, is partially dissolved, and leaves quartz residue; whilst the two last, when placed in a hot fire, exhibit white fumes, which settle on iron or charcoal, and are known by being yellow when hot, and white when cold.

The tenth, eleventh and twelfth piles may receive any *metals* that are present, as gold, platinum, copper, etc.; which may be known by their colors. In using this test for the metals the sample should be pulverized between stones.

The thirteenth may receive such as vary in color from a strong metallic-lustred white to a similarly bright yellow, which will contain, when in quantity, the arseniuret or sulphuret of iron, which, on being heated, will either evolve the garlic smell of arsenic, or that of sulphur, and the residue will become magnetic after sufficient roasting on charcoal, when quite cold.

The chloride of silver, if in minute division and small quantity, will mostly pass away; but, should it remain, it can be tested by harshly rubbing a bright and wet copper cartridge therein; if chloride or chloro-bromide of silver, it will whiten the copper with a silver coating, which can be also applied to the unpulverized chloride faces of the stone. Graphite will thus whiten copper or gold; but this can be rubbed off and is so different in color, having a bright, steel-like appearance, that it can scarcely occasion error.

In all cases, the lighter gangues will have passed away in the water, and it will seldom occur that more than two or three of the useful minerals will be present, and they quite different to each other, or you so indifferent to some of them, that they need not interfere with the more straightforward examinations, for such as will really concern you.

There is no very safe common-place test for silver, when in small or even paying quantities, as will be very plainly seen from the fact that one-thousandth part, or two pounds, scattered throughout a ton, will equal $37.70 in value.

It occurs, too, in so many mineralized forms, that the best judges are often unable to even approximate its value without an actual assay. If you have some *chemically pure* nitric acid, you can test silver, when in *paying quantities*, as follows:

Take about one hundred grains of the pulverized ore, which mix with its volume of powdered charcoal, and roast during continual stirring with an iron or brass wire, for fifteen minutes, at a red heat, until the charcoal is all burnt, so as to decompose any chloride of silver that may be present (which is insoluble in acids); remove the roasted ore to a tea-cup, and pour about twice its volume of nitric acid thereon, and then warm over a coffee-pot of boiling water, for some twenty-five or thirty minutes. Remove it from this position, and after it is quite cold, well settled and clear, you can test this solution for silver by pouring a few drops of salt water therein, which renders it milky, or precipitates a white chloride; as, also, by dipping a small piece of copper, as a strip from a rifle cartridge, in the *original* solution; if silver is present, the copper will be plated thereby. This roasting is imperative in all instances, as, even when the silver ore is in a soluble form, salt, or some soluble chloride, may be present in the vein, which, by immediately precipitating the silver from the solution to an insoluble chloride, unless the samples were rich, would falsify the result from this or any other *acid* test. (See the proof for chlorides thus precipitated, in the Alphabetical Chapter, under the head of Silver.)

The double treatment of silver ores by ammonia and nitric acid is too chemical and dangerously delicate for manipulation by amateurs.

Copper can be very conveniently precipitated on iron, steel, or zinc from a similarly treated sample; a clean, bright knife-blade being a ready and extremely delicate test, which must, of course, be applied before the copper test is inserted for silver, as being thus partially dissolved in the solution, it would otherwise show a treacherous false coat of foreign copper.

This method of water concentration is not directly valuable for the silver ores which are all too soft and friable, but it is *indirectly* useful, as it exposes the presence of such as are most likely to contain it and those which require an especial assay.

The silver ores named in the sixth and seventh lists, when they are dark, or cut freely, as well as such having a suspicious stain of chloride, or the lead, and zinc ores, are always worthy of an actual assay. The facts that all of the ores of silver worked by miners are comparatively soft, varying from about 1 to 3 in the scale (quartz being 7, and common salt 2), should be remembered, as well as their *not* being of a very pale metallic lustre, as it will guide you to such as should be tested, and away from the minerals having a pale metallic lustre, which are not silver ores.

This water treatment is thoroughly reliable for the assay of gold, platinum, and other metals, and oxide of tin, as described; as well as for the more tenacious ores of lead, antimony, copper, manganese, zinc, etc., from established mines of such, when free from confused mixtures.

For the actual assay of either of these by water, a quantity, varying from 10 to 2,000 grains, may be taken, and the residue of minerals or metals calculated by the rules laid down in Chapter III, Section III, on Water Treatment, and in the respective chapters on assaying each metal and mineral.

A most important part of this system of examination is that of comparison for specific gravity, which may be sufficiently illustrated by two examples; the first being that of yellow mica, which, when very thin, resembles gold leaf. If in doubt, you may become more positive by throwing some thin disks of gold in the test, when, on the repetition of the action of water, it will be seen that the supposed gold (of specific gravity from 16 to 20, as it is more or less alloyed), will take the concentrated upper position; whilst the mica (of a specific gravity of but 2.9) will oscillate more freely in the current of water, and settle at the lower end, or pass away over the margin under suitable inclination and side-sway of the vessel, just as you may desire.

The second may be platinum (of from 16 to 19 specific gravity), or a sample of graphite (of 2.1 specific gravity), and the only lustrous white substance present; now this, as well as one kind of mica (the two-axed mica), are, like platinum and gold, insoluble in any one acid; and graphite further resembles platinum by its infusibility in the ordinary blow-pipe flames; so that the acid and fire tests being inapplicable, this simple means is always at hand to separate and distinguish by greater stability or floatability, in the manner described.

These are extreme cases to show the means by which the ordinary pulverized samples of iron pyrites or yellow copper may be sprinkled in the former; or galena, or sulphuret of antimony, in the latter; or any other minerals that you would test, by using the one as a comparison for the other as to their relative specific gravities, as tin oxide (of about 7) against manganese oxide (of about 4), etc., etc., being of similar colors, or having other close resemblance requiring additional collateral evidence.

Two other important advantages from this preliminary water treatment, which should be now mentioned, are, that the gangues having been all separated and passed away, the confusions that would otherwise arise from their occasional interference with the more useful minerals' reactions, by their excessive annulling quantity, can no longer prevent direct tests being made: the parting of the desired minerals in heaps will also afford further means for examination, from their physical characteristics, which in some instances greatly assist the amateur in seeing which of two or more ponderous minerals may be seen with features that are, by other means, too similar; as those of lead and bismuth, which deposit their yellow oxides on charcoal, both when hot and cold, but whose metals and minerals are so distinctly different in appearance, that you may see which is present by re-observing the washed sample whence they were taken; or, if a small quantity of lead ore is with that of zinc, it will still more plainly show itself under this water treatment, and prevent your being deceived, by the overcovering of yellow oxide of lead before blast of flame, on what would, when alone, be changed on cooling, from yellow to the white of zinc; as also when tin and zinc are in company; or antimony and tin, etc., which are all so decidedly different in their mineral states, although similar in others, that it affords much more information on the subject than you can obtain from sources that are both beyond your knowledge and the facilities of your camp.

Copper may be detected, in all its combinations, in a very simple manner, by first roasting, then dissolving in acid and precipitating it, on iron or zinc, from its acid solutions, as described in the wet test for silver; or it may be moistened into a paste with hydro-chloric acid, and thrown into a fire, when, if copper is present, even in very small quantity, after the first intense blue flame, caused from the chlorine, has disappeared, the characteristic and beautiful green flame of copper will follow. If you have no acid, take either of the pulverized samples supposed to contain copper, and after first roasting, to intimately mix and well knead it with its bulk of wet salt, and candle-grease (lard, mutton, beef, or any other fat), and thus prepared it may be cast into a bright fire, when the characteristic colors, first blue and then green, of chlorine and copper, will also appear. Some of the copper ores will show the green flame by fire alone, and others will not require the preliminary roasting before acid treatment. This is exhibited better in the night, as the colors are much more distinct during comparative darkness.

If copper is present in the dark gray ores, it does not follow that silver is absent, as some of such carry this and other metals in constitutional forms, and they should be tested—or, more properly, assayed—for silver.

It will be seen that the seventh pile can also be very easily tested for copper, as both the black and red oxides give these flames most readily, even without any artificial preparation. It may also contain cobalt, nickel, iron, mercury, the red silver ores, and sulphuret of zinc, which bruise from a light to dark red, both wet and dry.

Cobalt may be known by being intimately mixed and fused with borax in an iron spoon, which produces an intense blue glass, that can be best examined by a lens, after pulverization.

Nickel produces, with borax, in the same manner, a reddish brown glass; but, as manganese gives a too similar, light or dark amethyst, this sample should also be treated, in a clean iron spoon, with carbonate of soda, when, if manganese produced the amethyst or purple, with borax, it would also show its very characteristic bluish green glass, by this easily applied and valuable collateral check.

These colored flux tests must be performed in a hot and clear, open fire, so that complete fusion may be produced in the midst of a free current of air.

Iron has been already explained; but another means may be applied, in the absence of a magnet or chemicals. Roast in some open vessel, at a red heat, for two hours, and after increasing the heat towards the end, allow it to gradually cool down with the fire itself, over night. Place this well roasted ore in an open saucer and just cover it with water; if iron is present, it will be exposed, in a day or two, by rusty water.

Copper ores may be tested in a similar manner, by strong vinegar, when the solutions will become bluish-green if allowed to remain for a few days.

Mercury can be examined by placing an equal quantity of carbonate of soda and the pulverized ore in a thin oil flask, and applying the flame of a lamp underneath, when, if quicksilver is present, it will, after being thus reduced by the carbonate of soda, be volatilized to the upper part of the flask, and condense upon the cold glass in minute metallic globules, which can be scraped together by a bent wire or other smooth and clean rod, for better examination, by naked eye or magnifying glass.

It may also be performed in an old gun or pistol-barrel, or even a clay smoking-pipe, by stopping its mouth, then firing up and driving out the fumes, to be then caught without the pipes, on a cold metallic substance; or, when it is treated with carbonate of soda, by inserting a cold coin in the escaping fumes, it will be amalgamated thereby, which may be known by its mercurial brightness after it has been rubbed, as the oxides from the other volatile minerals and metals would be thus wiped away.

The ruby silver of very similar appearance, should be tested, with its bulk of borax, in a small recess, of the charcoal, within a hot fire, for some ten minutes, and then removed and examined for metal. None of the other similarly colored minerals would produce a silver-white metal in this manner.

Zinc can be also tested on a piece of coal, which would, if placed in an open fire, be soon oxidized, and, on removing the charcoal from the fire, it may be seen that the *hot* oxide of zinc is yellow, and the *cold* oxide is white, when lead is absent, which will be thus known with great certainty by this method.

Tin, after it has been roasted, can be best examined by water, as all of its associates are thus easily separated, from difference of specific gravity, by roasting, pulverizing, and re-washing; excepting only the rare tungstate of iron (wolfram), when the concentrated sample must be washed with hydro-chloric acid, (which has no effect on tin oxide,) instead of water, as a last operation, so as to dissolve and remove this impurity. It is a singular fact that the sulphurets of lead and antimony are not found in the profitable tin veins, at least in quantities sufficient to interfere with the concentration of tin ores; which is most fortunate, as the galena would, by its too similar specific gravity, accompany the oxide of tin throughout all stages of water treatment, and both it and the sulphuret of antimony would so clog the furnace in the roasting, by their fusibility, that tedious acid treatments would have to be used for completing the process; the antimony can be very carefully separated by water, and after the residue has been dried, the bright lead-colored galena can also be either dissolved off in acid, or patiently extracted with the forceps from the resin-like tin.

Tin oxide is most characteristic for its notoriously persistent resistance to any alteration, either from unfluxed red roasting, water, or even acid washings; as well as for having a resin-like appearance, varying from cream color to brown black, which has a peculiarly rough feel under the finger and pestle. Garnet (plentiful in this country) in all of these, closely resembles tin oxide, excepting that of *specific gravity*, therefore the water treatment is most available, as—being about 4 against tin oxide of 7 —by placing any bright mineral, from about 5 upwards in its company on the concentrator, garnet can be passed over the margin, and its want of gravity may thus, by comparison, be exposed, which is in itself an equally good test for tin. Garnet, too, may be so easily obtained in a crystallized state, free from other substances, that its specific gravity (which is obtained by dividing its weight in the air by the difference of its weight in air and in water) will inform you that it is not tin. Tin decrepitates slightly when in the stone, and garnet does not.

For example, a stone that was supposed to be tin weighs in 80.4 grains (or ounces, etc.), which, when suspended under the scale pan by a very light thread, and a basin of water is carefully raised from beneath so that the stone shall be just covered therein, it then weighs 60.3, the difference of these weights would be 20.1, then $\frac{80.4}{20.1}=4$: this specific gravity of 4 is insufficient for tin; but it may be garnet.

These facts evince that if any resin-like and heavy pulverized ore, after having been roasted and re-pulverized, still resists this water treatment, it must be the oxide of tin, or the tungstate of iron, or both together, which hydro-chloric acid will finally settle, by dissolving the latter only.

Tin crystallizes in square prisms, or octahedrons, whilst garnet forms the dodecahedron and its modifications.

For the assay of tin by water, take a hundred grains (or parts,) which concentrate, and weigh the residue, then multiply it by 78.4, and divide by 100, by removing the decimal point two figures to the left, for the actual quantity of pure metallic tin; or, which is the same thing, and more simple, move it in the multiplier thus: .784 from 78.4. For general average smelting returns, multiplying the weight of the residue by .72 will be nearer the realized quantity.

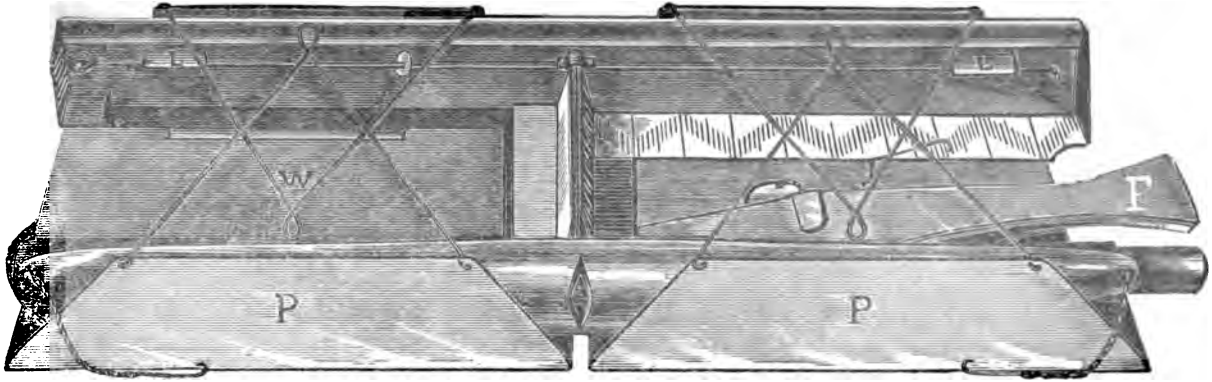
This system is much enhanced for practical value from the facts of its being a comparative measure for the waste occasioned by water on the large scale, and, for the gold assay, it is a reliable test of what can be obtained, without roasting, by this miniature amalgamation with mercury.

As stated in another part of this work, the expensive microscope is, for many reasons, not adapted for your practical purpose, and has only been particularly recommended by those unacquainted with more studied and exacting modes, because they would absurdly prefer to jump over the real work, and follow this "royal road."

Figure 24.

E "LITTLE WONDER," SELF-CALCULATING, SAMPLE AND BUTTON-WEIGHER.—Patented.

When in good order for delicate weighing, this little beam should oscillate from 15 to 18 times per minute, and turn the pointer a half-inch with the one-hundredth of a grain placed upon the end. If not thus sensitive, it has been bent out of form.



INSTRUCTIONS FOR WEIGHING SAMPLES, AND VALUING BUTTONS, BY THIS APPARATUS.

1. For Gold Assays.—Place the tabular beam on the central knife, and suspend the pans P.P. under its crooks. Weigh 602.7 troy grains, by the long brass bar weight, concentrate by water, smelt and cupel by furnace *or blow-pipe*, and value as follows: Place the little lever in position, balance by paper disk, drop the button of gold into the conical cup, and see which of the rider weights will balance it when moved from the end of the beam by way of the ninth, eighth, seventh, sixth, fifth, fourth, third, second, and first, long cross-lines, upon the scale, but *not beyond or within the first line.* If the largest or "red rider" is too large, try the "white rider" in *same manner*, and this being too large, the "blue rider" *will then value alone.* In all cases where *more than one* rider is used, the larger weights are simply placed opposite lines, whilst only the *smallest* is moved to finish balancing. In valuing buttons from samples thus weighed and balanced, the red rider equals $100 for each cross line, the white rider equals $10 for each cross line, the blue rider equals $1 for each cross line, and 10 cents for each short diagonally-placed mark, per ton of rock. For example, if the red rider sat opposite the *ninth* line, the white rider opposite the *sixth* line, and the blue rider just *two marks* beyond the *fourth* line, the value would be $964..20 cts. per ton.

2. For Silver Assays by furnace.—Weigh the sample as before, but with the S. C. shaped brass weight, 37.7 troy grains, from Box W, and the value will be found just as above. Or a silver button, *from this quantity of ore*, if of the same weight as the gold button, would also be worth $964..20 cts. per ton. If this button should also contain gold, you may value it separately, by multiplying the properly parted and ignited residue by 16.

3. For Silver Assays by Blow-Pipe.—Weigh in aluminium pan, balanced by white horizontal clasp on small beam, using the S weight from Box W, then smelt by my method as herein described. In silver buttons *from this quantity*, red rider equals $1000 for each cross line, white rider equals $100 for each cross line, blue rider equals $10 for each cross line, and each diagonally placed mark represents $1, so the same button would value $9642 per ton.

4. For Thousandths Fine and Percentage.—Use red rider for sample, and rebalance the cupelled bullion or smelted button, with the *same red rider* weight, which would then sit just opposite its decimated, fractional value. The "red, white and blue" may also be conjointly used for closer declination

CHAPTER VI.

NEW METHODS, BY BLOW-PIPE, FOR THE DIRECT EXAMINATION OF MINERALS, FOR THEIR USEFUL AND PROFITABLE ELEMENTS, AND FOR ASSAYING GOLD, SILVER, AND BASE METALS.

The following safe, simple, and direct tests, have been devised and arranged for ordinary men, so that they may know what useful elements are present in minerals, without having to ponder over and puzzle themselves with all the irregular and complicated random rounds of re-actions, in qualitative analysis; which can only be fully comprehended after years of close study and arduous practice.

DIRECT ANALYSIS FOR USEFUL ELEMENTS.

Before entering on the following course of tests, it will be necessary that the practitioner should be acquainted with, and able to perform the various manipulations described in Chapter IV, of Section III; as, how to produce the oxidizing and reducing flames, page 175; the discrimination on charcoal, pages 176 and 177; smelting with fluxes on charcoal, pages 180 and 181; examination in forceps, page 182; discrimination by fluxes in the platinum wire loop, pages 182, 183, and 184; the uses of open, and close ended, glass tubes, over spirit lamp, at pages 185, and 186; and examination by smelting and water washing, for small quantities of the metals.

The practically useful and profitable minerals worked by miners, are composed of the following elements:

Antimony, arsenic, barium, bismuth, chlorine, chromium, cobalt, copper, iron, lead, manganese, mercury, nickel, sulphur, tellurium, tin and zinc; with the lime and magnesian, aluminous and quartzose, rocks.

Before commencing your tests, write these names upon slate or paper, and then proceed as follows:

Thoroughly fuse some of the finely pulverized ore with carbonate of soda, within the small terminal eye or loop of platinum wire, just before the point of the oxidizing flame; and notice the color of the glass.

If the glass is pale yellow? Chromic acid is present, from some chromate ore.

If the glass is bluish-green? It has been produced by manganese.

If of a copper red? From copper reduced by this flux.

If of a lead colored enamel? From reduced lead.

If not thus colored, erase chromium and manganese from your list, and test for the remainder, by fusing in similar manner with borax before the oxidizing flame.

If the glass is blue? The metal is cobalt.

If light bottle green? Iron.

If amethyst? Manganese. (But this would not be present if the carbonate of soda failed to show it.)

If of a reddish brown? Nickel.

If green? Chromium or copper. If this color proceeds from copper, it may be reduced and destroyed by the yellow flame, but you have other tests for both.

If neither color? Expunge copper, cobalt, iron, and nickel from the list.

Place a small piece of the mineral, of about the size of a grain of wheat, upon un-fluxed willow or pine charcoal, and subject it to the oxidizing flame of the blowpipe, until an intense heat is produced, which continue for about one minute.

If there is no white, or yellow oxide, deposited on the coal, the specimen does not contain antimony, arsenic, bismuth, lead, tin, tellurium, or zinc, and those may also be erased from the list. See that this color is produced from the mineral and not from inferior coal.

Fuse this same sample for about two minutes, in the strongest heat f the reducing flame, and when cold it may be applied to the magnetic needle, as a collateral test for iron.

If you wish to examine for the rocks, do so now.

Quartz, scratches glass, before and after, strong ignition.

Lime, would now dissolve, or slack in water.

Baryta is very heavy for a rock-like mineral, and when moistened with hydrochloric acid, gives a green color before the oxidizing flame. (The carbonate effervesces with strong acids and the sulphate affords sulphur reaction on silver.)

Magnesia and alumina, when moistened with a drop of the "solution of cobalt," and again strongly heated upon charcoal, will respectively show their characteristic flesh, and blue, colors.

If a white oxide is seen on the charcoal, at some distance from the test sample, it will be from antimony, arsenic, or tellurium.

*Antimony, has a pleasant flower-like odor, arsenic, a disagreeable garlic stink; and the naked oxide of tellurium, will burn off, with a green flame, before that from the blowpipe.**

If the oxide on the charcoal, is white, and close to the test sample, it is produced from tin.

If the oxide is yellow, when hot; and white, when cold; it is that of zinc.

The fused oxide of tin when moistened with nitrate of cobalt, and

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*I have discovered the following test, which is not only easy in use, but quite pretty and reliable. Dissolve a crystal of nitrate of silver in a small quantity of water, moisten a piece of white porous paper therewith, and dry it over a fire. Mix the suspected sample with twice its weight of carbonate of soda and fuse it upon charcoal to a clear slag. Wet a small and clean piece of this slag with water and place it upon the test paper for a few minutes. If arsenic is present this prepared paper will be very distinctly stained to a reddish brown, which is more correctly exposed underneath the paper, where it shows only the chemical reaction, quite free from any mechanical debris.

By this same mode of fusion with carbonate of soda and testing on porous paper thus soaked in nitrate of silver, chromic acid gives red, manganic acid black, and vanadic acid a yellow color. These test papers must be kept from the light.

re-heated before blowpipe, becomes of a greenish blue color; whil the oxide of zinc, when thus treated, changes to a bright green.

If the oxide on the charcoal is yellow, it is either from lead o bismuth.

Smelt on charcoal with carbonate of soda, and these minerals wil be thus reduced to metals. Bismuth is very brittle, and lead ver ductile, under the hammer.

You have now thoroughly tested for all but chlorine, copper, mercury, and sulphur, and should mark off those absent.

Copper. *Copper would have colored the first bead of carbonat of soda, but it may now be more effectually tested and reduced on charcoal, when fluxed with say, equal parts of carbonate of soda and sugar, to irregular nuggets of red metal.*

It may be also detected in very small quantities after it has been roasted before flame, then moistened with hydro-chloric acid, and re-flamed; as it first gives the blue flame, from the chlorine of the acid, then finishes with the beautiful green color of copper.

Chlorine. *Fuse in the platinum wire a bead of microcosmic salt, with as much oxide of copper as it will absorb, then add the liquid or solid, to be tested, and place it into or before the flame; if chlorine is present it will show its characteristic blue.*

Sulphur. *Lay the first bead formed with carbonate of soda, or any other of the slags from the smeltings with that flux, on a moistened silver coin, and if the ore is a sulphuret, it will, by forming the soluble sulphate of soda, stain the bright silver, from brown to black according to the quantity of sulphur present, or time given for the discoloration.*[*]

Mercury. *Place a small grain of the raw ore, on a piece of gold, copper, brass, or silver, and impinge the flame from the blowpip thereon, for a few seconds, so that the heated current, beyond the te sample, may pass close down upon the cold metal, when—if it be an ore of mercury—its fume will condense and amalgamate the surfac*

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[*] Warming the silver coin greatly facilitates this test, for a very small quantity, by both *increased affinity* and *concentration* of the watered sulphate.

of the metal, which can be more distinctly observed, after it has been rubbed with a wet finger.

The metal may be again cleaned by warmth, which corroborates this very efficient and practical test.

Thus, the qualitative analysis of the profitable base minerals may be readily and thoroughly completed, by men knowing nothing of minerals *at sight*, and the particular metal or metals found, may be then assayed for correct quantity, by either of the convenient modes.

The short abstract statement of operations for testing by the above mode, as given beneath, may be more easily remembered.

1. Test, with carbonate of soda in platinum loop, for *colored beads*, from chromium, manganese, copper and lead.

2. Test, in similar manner with borax, for *colored beads*, from chromium, cobalt, copper, iron, and nickel; and also look for *amethyst color*, as collateral proof of manganese.

3. Test, on charcoal, for iron, *by the magnetic needle;* for the oxides of antimony, arsenic, bismuth, lead, tin, tellurium, and zinc, by their color, etc., etc.; and for the rocks, of quartz *by hardness*, lime *by its solubility*, baryta *by weight, and color of flame with hydrochloric acid*, and of magnesia and alumina *by the flesh and blue colors produced*, in manner as for tin and zinc, *by "nitrate of cobalt" solution.*

4. Test for copper, by *actual reduction*, and *color of its flame when dissolved in hydrochloric acid;* for chlorine, by a copper saturated bead of microcosmic salt, *from its blue flame;* for sulphur, by fusion with carbonate of soda, and dissolving the mass on a silver coin, *by its brown color;* and for mercury, by hot blast to the sample when placed on a gold or copper coin and other suitable metals, *from its amalgamation.**

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* Being the inventor of the several instruments alluded to at page 162, I have only illustrated the leading pair of patented appliances, the "Wee Pet" and the "Little Wonder," but the "Automatic Smelter," "Laboratory" and "Little Wonder" Combination, of coat pocket size, would be of immense benefit to workers by the methods of this chapter for testing and assaying.

A NEW MODE FOR TESTING AND ASSAYING ALL OF THE SILVER ORES BY COMMON BLOW-PIPE.

There is no easily performed, quick and reliable test for low grade silver ores, or for gold in *sulphuret of iron*, or even smal quantities of *free gold* in quartz, short of the actual assay by smelting and cupellation; so that any more ready means for obtaining such assays, without cumbrous and expensive furnaces, will be of immense value for explorers, who may not be fully educated in mineralogy.

The assaying machine, described in this work, was especially contrived for the traveling purposes of prospectors; but its cost prevents general use, and as the system followed in books, for the assaying of silver by the common blow-pipe, requires much skill and practice, I now give the far easier, and much better method, as performed by my pupils, which they have not only more readily executed, but invariably preferred.

(See Figure 24. The Little Wonder.)

ASSAYING OF SILVER ORES, BY COMMON BLOW-PIPE.

1. Select, or cut to form, a cubical, or cylindrical piece of solid pine or willow charcoal, about one inch and a half in diameter, and bore or sink a round half-inch shaft, one inch deep, in the *center* of one of its facets; and then drill or drive a *quarter-inch* transverse blast-hole or tunnel, from one of its sides, to communicate therewith, so that the *bottom* of this tunnel shall enter, at a *quarter-inch* above the lowest part of the shaft.

2. Take about ten grains of the sample, as carefully averaged by the method described at page 159, and after reducing it to an impalpable powder, weigh out *two grains* or 3.77 grains, by the S-shaped weight of the "Little Wonder," as explained by Figure 24, for the assay, (which is nearly four times as much as can be treated by the old method.)

3. Weigh thrice as much litharge, (a universal flux for all the matrices,) and intimately mix it with the ore.

4. Cast or brush this mixture down to the bottom of the shaft, into the charcoal.

5. Weigh six times the S-shaped weight, of test lead, drop t on the previously fluxed ore, so that it may quite cover it, and still leave a small air passage from the tunnel to the shaft.

It will be better to make a measure for these fluxes, by shortening a small pistol cartridge; and one will answer for both lead and litharge, as the former is just twice as heavy as the latter.

6. Trim your wick, fill the lamp with the best olive oil, and see that a superlatively good flame is produced.

7. Now take the charcoal in your left hand, and after inclinng the *shaft* towards the eye, and the tunnel to the *wick*, blow a *gentle* blast over the wick so that the whole flame may pass at about 10° downwards from the blow-pipe into the *tunnel*, and thence through it and the shaft, for some two or three minutes.

8. When the litharge fuses and waxes over the face of the sample, it is secure from all danger of loss, and your attention must be devoted to producing the greatest possible heat, by proper strength of blast and distance from the wick.

About ten minutes is generally sufficient for the completion of the smelting, but the novice will be longer.

Those who cannot blow continuously, will find, that if towards the end of the process a piece of charcoal, about the size of a pea, is placed in the shaft, the radiation or loss of heat will be but little during breathing time.

It will be a great help in very stubborn ores to sway the lead button somewhat violently from side to side, so that it may break through and traverse the slag for the collection of stray buttons, and to also change the blast from the tunnel to the shaft. You need not fear blowing too long in such samples, as it will cause no waste of silver, and leave less to cupel.

9. Allow the assay to get *quite cold*, cut out the slag and metal button, fold it in a piece of rag, place it on some hard support, and hit it once or twice with a hammer, or hard stone, to clear the slag away, so that the button may be further solidified by hammering and then brushed quite clean for cupellation.

10. Take the same or another piece of charcoal and scoop out with your knife, a ragged basin on one of its sides, about an inch in diameter and a half-inch deep, which ram full of fine moistened bone ash, and compress the surface to a suitable concave, with a base metal teaspoon or other properly shaped smooth instrument. Then slowly dry the ash, either by a fire, or at some four inches beyond the flame from the blow-pipe.

11. When quite dry it may be held close to the flame from blow-pipe, brought to a red heat, and the smelted button quickly placed thereon for refinement, by oxidation, as follows:

12. Hold the supported metal in the hottest mixed flame from the blow-pipe until the metal is thoroughly fluid and almost white hot, then withdraw it a very little, so that the *point* of the blue oxidizing flame may nearly reach the front of the button. Great care must be taken at this stage of the process, to place the cupel at suitable distance, for although the flame must be kept for oxidizing, the heat should also be sufficient to keep the metal quite molten, whilst the bone ash absorbs the oxides of the base metals. Blowing alternately on the sides of the button, for about twenty seconds, so as to thoroughly fuse the frozen oxide, greatly facilitates both the oxidation into air and infiltration of litharge into the more intensely-heated porous ash.

This operation requires considerable heat, and is perhaps the best way to study the effects produced by proper position of blowpipe, strength of blast, and appropriate distance from the flame.

A little practice will enable you to perform, in this manner, these operations of smelting and cupellation, for the assay not being encumbered with massive cartridge and borax, but mixed with this fusible, heavy, compact flux, and thus enclosed, as if in an actual furnace, the smelting can be much better effected; whilst the oxidation can also be accomplished far easier by any one, on the charcoal, than when the bone ash is enclosed in the cold iron moulds so generally recommended in books.

It must be confessed, that having so much respect for the old masters, I had implicitly followed this recommendation for many years, without any thought of its advantage or disadvantage, until I was suddenly impressed with the idea that the enclosing iron was not a "reservoir of heat," as stated, but so much a reservoir of cold, that it was always difficult to keep the accumulating oxide of lead from freezing upon the surface of the bone-ash.

No expensive tools are required for this method.

The modes for weighing and valuing are explained by Figure 24, and Chap. VIII; but it may be added that valuations may be roughly made either by the red or white rider alone, although it is always better to use more than one, unless the button is so small that the blue rider commands it.

In *actual mining and milling*, you can also employ *two white* *riders*, the one to move for balance, whilst another or others may sit still upon the end of the lever as $100, $200, $300, &c., with the movable rider's amount simply added as, say $142, $242, $342, per ton, &c., &c.

Do not touch the steel beam with anything that has been magnetized, as it will, by transforming it into a dipping needle, sadly interfere with its balance. If it should occur, it may be rectified by warming the whole beam in the flame of an alcohol lamp.

ASSAYING OF GOLD—BY WATER AND BLOW-PIPE.

Take from the finely pulverized sample of quartz say 200 grains, or 602.7 grains if you wish to dispense with calculation as explained under this heading, which carefully concentrate by water in the manner recommended in Chapter III, Section III; and you will generally find that the weight of the dried auriferous residue, will be less than the quantity required for this mode of assay. A little pure muriatic acid and sometimes roasting for sulphurets, may be often used to great advantage to pass away the base metals in solution, when the thus further reduced residue, after having been washed in water and dried, can be *fluxed and assayed as just described for silver ores.*

For methods of weighing and parting the buttons and valuing silver and gold assays, see Index, Fig. 24, and Foot-note.*

This is one of the most useful applications of the wonderfully efficient little blow-pipe, as a careful operator, when thus aided by water concentration, can actually make an assay for gold; and just as correctly too as can be made by any other method.

Those having doubt about the waste from water, may concentrate the sample in a suitably shaped, wide-mouthed bottle, so that it may be so thoroughly wetted, that any loss by way of floatation, will be much less than by battery.†

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*In parting buttons containing gold and silver by boiling nitric acid, it is necessary that there should be at least three times as much silver as gold, and if not present it must be added, *after weighing*, for this purpose of complete separation. See Index for other headings on this subject.

†This is also an admirable means for the collection of minute sponges of gold, after they have been parted from silver, in nitric acid; by thus carefully smelting on charcoal, with the fluxes of litharge and lead, and re-cupelling to a pure and round ball.

ASSAYING OF LEAD AND TIN BY BLOW-PIPE.

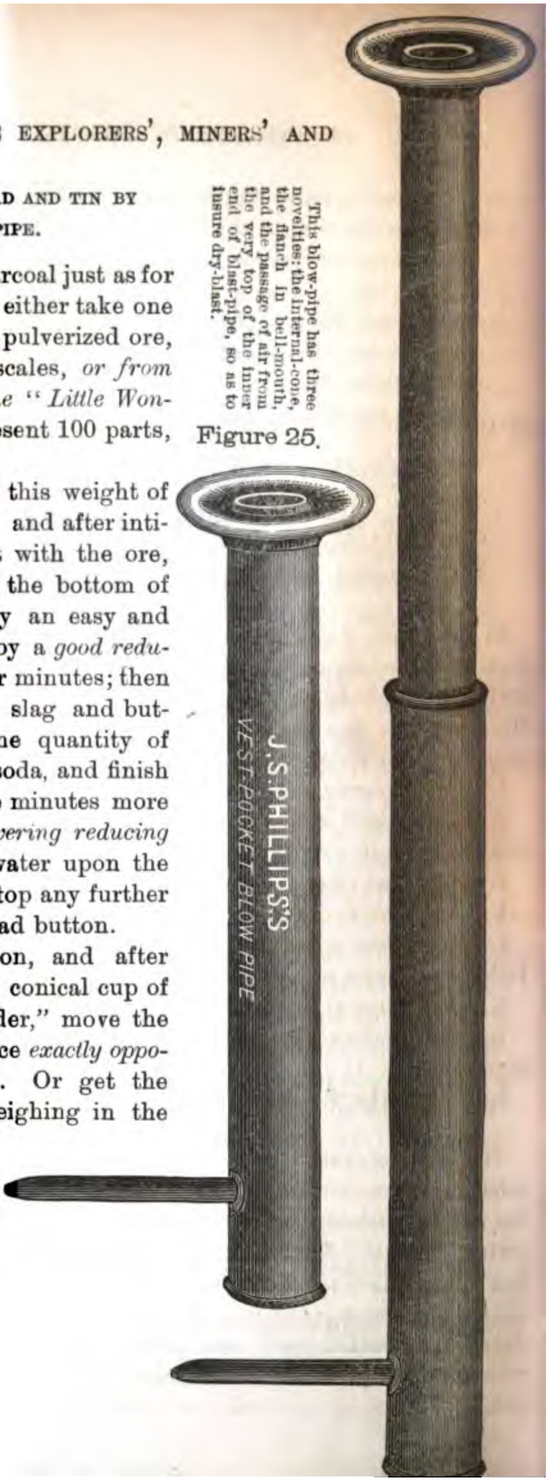
Prepare the charcoal just as for gold or silver, and either take one grain of properly pulverized ore, by any ordinary scales, *or from the red rider of the "Little Wonder,"* so as to represent 100 parts, for assay.

Now add twice this weight of carbonate of soda, and after intimately mixing it with the ore, and placing it in the bottom of the shaft, smelt by an easy and continuous blast by a *good reducing flame,* for four minutes; then *quickly* cover the slag and button with the same quantity of the carbonate of soda, and finish smelting by three minutes more of the *perfectly covering reducing flame,* and drop water upon the hot coal, so as to stop any further *oxidation* of the lead button.

Clean the button, and after dropping it in the conical cup of the "Little Wonder," move the red rider to balance *exactly opposite the percentage.* Or get the percentage by weighing in the ordinary manner.

TIN ASSAY.

Concentrate closely by roasting, muriatic acid and water; flux with cyanide of potassium instead of carbonata of soda, then smelt the sample alue percent- for lead.



This blow-pipe has three novelties: the internal-cone, the flanch in bell-mouth, and the passage of air from the very top of the inner end of blast-pipe, so as to insure dry-blast.

Figure 25.

CHAPTER VII.

AN ALPHABETICALLY ARRANGED RECORD OF THE EFFECTS PRODUCED BY WATER AND FIRE, SOMETIMES FURTHER ASSISTED BY WATER AND CHEMICAL RE-AGENTS, ON THE MINERALS AND SUCH OF THEIR COMPOUNDS, AS WILL BE PRACTICALLY USEFUL AND PROFITABLE TO THE EXPLORER, ASSAYER, MINER, AND METALLURGIST.

In the discrimination of the minerals, it is sometimes very important to ascertain, by comparison, their hardness; and the following list of ordinary and well-known materials first selected by Mr Chapman as a comparative scale will be found most convenient for your purpose:

1. Yields *easily* to the nail.
2. Yields *with difficulty* to the nail, or merely receives an *impression* from it. Does *not scratch* copper.
3. *Scratches copper;* and, being *equally hard,* is *scratched by it.*
4. *Not scratched* by copper; *does not scratch* glass.
5. Scratches glass *with difficulty, leaving* its *powder* on it. Yields readily to the knife.
6. Scratches glass *easily.* Yields *with difficulty* to the knife.
7. Does *not yield* to the knife. Yields *with difficulty* to the edge of a file.

8, 9, 10. Harder than flint.

The specific gravity is also very effective for discriminations of solid and homogeneous minerals which are otherwise most similar in color, texture, etc.; and it may be ascertained in the following manner: Take a piece of small strong thread about one foot long, which place in one scale pan, and balance the lever thereto, by putting small pieces of matches or some light substance in the other pan. Weigh the stone to be tested, which we will call 2.25 ounces; next take the stone, and fasten it by a suitably knotted loop to the middle of the previously balanced thread, and suspend it beneath the same scale pan from which the thread was taken, by knotting it over the top of the pan; and after *re-weighing* the stone, to see that no difference has been caused by jostling, etc., raise a basin or glass, that has been nearly filled with water, until the stone is just completely immersed in this water; after particularly assuring yourself that all the air globules have left the stone, place in this pan sufficient weights to return the scale beam to balance as before, being careful to notice that the stone is still slightly submerged. Now, supposing that .72 had been required to thus reproduce the balance, the specific gravity of the stone would be found by merely dividing the *larger real weight of* 2.25 in the one pan by the *smaller re-balancing weight of* .72 in the other pan; or the *greater divided by the lesser:* $\frac{2.25}{.72}=3.125$ the required *specific gravity;* or, in other words, "The specific gravity is ascertained by dividing the weight of a substance in air by the difference of its weight in air and in water."

For the reasons that much more extended study than generally prevails would be required for beneficial discrimination, and that the profitable minerals worked by the miner are either mixed, massive, or imperfectly crystallized, I have relied on specific gravity and crystallography as little as possible, and then only where the form is known to be pure, or is generally well marked, and easily understood. *(See also Chapters III, IV, V and VI, Section III, for various manipulations and modes.)*

ALBITE (SODA FELDSPAR).

This mineral is sometimes found in place of the common potash feldspar, in the granite rocks.

It is more generally distributed in North America than elsewhere. It is very similar to common feldspar in hardness and appearance (excepting its crystal form, which is that of the modified oblique rhomboidal prism); it is, however, generally of a more tabular fracture and glassy whiteness.

It may be more promptly and decidedly recognized and distinguished from the common feldspar, before the purely blue flame from blow-pipe, which is changed to yellow from the presence of soda.

The other spars of this family are of more interest to scientific men than practical miners.

ALUMINA.

This mineral is the chief component of fire clays. It may be detected when quite dry, with great facility, by applying it, for but a moment, to the tip of the tongue, and as suddenly withdrawing it; if alumina is present in practical quantity, the sample stone will reveal its characteristic desire for moisture by adhering to the tongue.

Clays are generally white, dirty white, yellow, or pink, but sometimes from red to brown, depending on the coloring matters which may be present.

As dry chalk (a somewhat porous carbonate of lime, but, I believe, not found in America) resembles it in many of these colors, as well as by slight adhesiveness, it should be also tested by fire or acids. Chalk (like the other carbonates of lime), after it has been burned in a strong fire for some twenty minutes, or before the blow-pipe's flame for two minutes, becomes caustic, and slacks in water; it also effervesces when moistened by any strong acid; a good clay stone is not affected by either, and thereby they may be distinguished.

A more delicate test for alumina, either when free, or after it has been separated from metallic minerals, in the manner described in a former chapter on the Discrimination of Minerals by Water, is that performed on charcoal, before the tip of the blue flame and moistened with nitrate of cobalt solution, which then gives a characteristic, pale blue color, after the pulverized mass has been again strongly heated in this flame, when the sample becomes quite cold. Pulverize this resultant stone and the smaller, freshly broken grains, will expose the color much better.

ANTIMONY.

This metal is obtained from its sulphuret, which is very plentiful throughout the Pacific States and Territories. It somewhat resembles fine-grained galena, being of a bright metallic lustre, with a lead-gray streak and powder, composed of antimony 73, sulphur 27; hardness 2; specific gravity, when pure, from 4.5 to 4.6, so that, as galena (the sulphuret of lead) is from 7.5 to 7.7, it takes a correspondingly lower position, in water treatment, on the concentrator. When one or both are present, the well-known yellow sulphuret of iron (iron pyrites), of from 4.8 to 5.1, or white arsenical iron pyrites, of 6.3, will serve to show, by comparative positions, the presence of either, or both, on its upper and lower sides, when they are not too intimately combined. This is an ever ready and good practical test, when others fail to inform you with sufficient certainty.

It also fuses very easily, even in the natural flame of a candle; and before the blow-pipe, upon charcoal, to a *black, waxy slag*, from which its voluminous white oxide arises for some time after the flame has ceased to play thereon, it also deposits on the charcoal at about three-fourths of an inch from the slag. These fumes are somewhat fragrant and may smell of sulphur, but must not afford the garlic stink peculiar to arsenic, which also gives out a white oxide, but *does not fuse to the waxy slag*.

Sulphuret of antimony may also be melted over a lamp, or fire, and even in an iron spoon, when the white oxide will ascend, coat the rim of the spoon, and smell as above.

If lead is present, a partial alloy with antimony would be the result on charcoal with carbonate of soda, some of the antimony would still arise as before and show the smoke of its white oxide, as it is much more volatile than lead, and this is not its reducing flux. The lead oxide is yellow.

ARSENIC.

Arsenic may be oxidized to white fumes, but less voluminously than antimony, which also whitens the charcoal and iron. Arsenic cannot be fused to metallic state on charcoal, nor can its ordinary ores be melted as those of antimony to a waxy slag, but may be reduced to metal in a glass tube, with fluxes, by careful and perfectly close treatment.

Its ores are all dissimilar to those of antimony, when water-washed; and emit a disagreeable garlic stink if heated, in fire, before the blow-pipe's flame, in a glass tube, or any other manner; both of which are very characteristic differences. I have used another very efficient and pretty little test, by first fusing the pulverized mineral with carbonate of soda upon charcoal and placing the moistened slag upon a previously prepared piece of porous paper that had been soaked in pure nitrate of silver and dried, as fully described in my new, direct method, for blowpipe analysis, Chapter VI, Section III.

ASBESTUS.

There are several varieties of this mineral, but that called common asbestus may sometimes be mined at a profit, as good samples realize from $15 to $45 per ton.

It may be known by specific gravity of 3. peculiarly fibrous or wood-like structure, and cotton or silk-like lustre, varying in color from pale green to white. It stands the ordinary heat of fires, but small pieces or fibres may be fused by blow-pipe to a grayish enamel. Garments made from such material are cleaned by fire.

It has generally been found in steatitic rocks, and it is chiefly composed of silica 56, magnesia 27, lime 14, iron 6, and alumina 2. It forms in needles, more or less aggregated, and I have a very curious and valuable specimen that has actually crystallized, or in a manner vegetated in separate acicular stalks, from the surface of a stone of steatite and cinnabar, during its rest upon the shelf of my laboratory.*

Asbestus is used for fire-proof clothing, and to mix with other fire-resisting materials in general manufactures.

BARYTES.

This mineral bears the common name of heavy spar, and has been mostly extracted for the adulteration of white lead paint, where labor is low, but is of little value to the American miner.

It may be distinguished from other spars by specific gravity, and from heavy metal-yielding minerals, by not producing metal when smelted on charcoal with flux.

It is mined in two conditions, as carbonate and sulphate; the former will effervesce, like all carbonates, in any strong acid; and a good test for the latter, is that for sulphur on silver given under the sulphur heading of this chapter.

To prove the presence of barium you may concentrate a sample in water, then thoroughly roast for at least an hour to expel *all the sulphur*, and dissolve the remainder in hydrochloric acid. If the solution is then quite clear (being free from sulphur), you may test it by pouring in a drop or two of sulphuric acid, which would render it milky for small quantity and curdy for a large quantity. The pure carbonate would not require roasting.

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* The component parts of asbestus seem to vary greatly, by either differently constituted samples or accidental outside elements, as scarcely two samples agree in results, and the above must only serve as a rough approximation.

The outer flame before blow-pipe is colored pale green by all barium ores, but be sure that copper is not present, which acts in very similar manner.

BISMUTH.

The ores of bismuth are still more fusible than lead, and are easily reduced to metal in the yellow flame of the blow-pipe, when fluxed with carbonate of soda and supported by charcoal. to a reddish white metal, which is very brittle and not ductile like lead, under the hammer; so that a flattened button breaks into small pieces, and thus distinguishes it from the very ductile lead, which also deposits a yellow oxide on charcoal.

As the *ores* of bismuth are all different in color as well as specific gravity, the method described in the chapter on Water Concentration assists to a high degree in the more certain and direct recognition of either.

The mineral is, however, scarce, and seldom conflicts with those of lead. When bismuth is dissolved in nitric acid, a copious addition of water to this solution precipitates its white oxide.

BORAX, BORACIC ACID, OR BORATES.

Any profitably valuable sample of borax (biborate of soda and water) may be detected before the oxidizing flame, after dipping a small looped platinum wire into strong sulphuric acid, and then dropping a small quantity of the pulverized substance supposed to contain biborate of soda (or any other boracic acid compound) thereon. After some five minutes have passed, for the partial solution of the substance, place it just before the point of the small blue flame, when, if boracic acid took any part in forming the mineral, the outside of the flame will be colored green.

A still more exacting test is to dissolve in a saucer, or other suitable vessel, a thimbleful of the finely powdered borate substance, in twice its volume of strong sulphuric acid, for ten minutes; and, after adding about thrice this volume of alcohol thereto, to stir well, and light the alcohol into flame, when, if boracic acid, or *any* borate, is present, the margin of the flame ill be tinged green. I have thus exposed the presence of the ne-thousandth part of borax. *To be certain that the borate is hat of soda (borax), you may also test for soda by color of flame,* and with cobalt in the platinum wire before the blow-pipe.

Be sure that neither copper nor phosphorus is present, as they give similarly colored flames.

The water from a lake may be tested in the same manner, but with much less of the acid.

As the only object of the alcohol is to provide the medium of flame, any *safe* inflammable liquid, which is in itself free from this color, will answer.

CHALK.

The blow-pipe flame, both on charcoal and in forceps, renders it lustrous, and, after some five minutes of this intense ignition, it affords a caustic lime-like taste and may be promptly slacked in water, like ordinary kiln-burned, commercial limestone.

A stone, after being exposed for one hour in the greatest heat of a common fire, likewise becomes caustic, and slacks in water.

It is of different colors, and always streaks, bruises, and marks accordingly, from being more friable than the other carbonates of lime, which, in common therewith, before ignition, effervesce in all strong acids, and act similarly, during and after, intense heat. (See lime and magnesia.)

Aluminous clays also streak, and adhere to the tongue; but, under fire and acids, they act differently; for which see Alumina.

CHLORINE.

When in combination, chlorine is most easily detected with the terminal eye of platinum wire, by fusing a glass from microcosmic salt (phosphate of soda and ammonia), and *saturating* this glass with copper, by dipping it in oxide of copper (or into mineral copper, *thoroughly oxidized* before the blue flame and then fused in this flux), until this resulting glass shows a greenish blue, cold bead. This being obtained, dip it into the liquid or substance to be examined, and replace it beyond the flame's point, in the hot current of air; if chlorine is present, it will be indicated by a clear blue flame, which, though sometimes a mere border and but transient, is always distinct. This being also a test for copper, its green flame will follow.

Chlorine gas, liquid chlorine, chlorine water, hydrochloric acid, and all soluble chlorides, as common salt, sal ammoniac, etc., precipitate chlorides, when passed over, or into, the nitric acid solutions of silver, lead, or mercury, uniting immediately therewith, into insoluble chlorides; which, being separated *by water treatment* from the acid, may be further distinguished by ammonia, in which chloride of silver is completely dissolved; that of mercury is thus oxidized black, whilst lead remains unaltered, by either the acid or ammonia.

COAL.

All kinds of coal can be ignited before the blow-pipe, into flame, which continues for some time after the cessation of the blast; the flame is, however, more a measure of its gaseous than calorific quality, as some enduring anthracites give little flame, but supply a long-continued combustion, leaving a trifling residue of unconsumed ashes.

In the bituminous coals, the more crystalline, brittle, and bright, the better the quality.

The best parlor coals are generally the worst for steam engines, and *vice versa.*

The lignites are distinguished from the true or older and better black coals by scratching and pulverizing brown.

A good approximate and very quick test of its quality for household purposes may be made by carefully and gently flaming a one grain stone on charcoal, platinum foil, or a very thin sheet of iron, for a few minutes, and noting its quality of cumbustion, diminished weight, and composition of its residue for stone, clinker or ashes.

See the Methods of Examination for Practical Men, in Chapter V, for approximate value by iron spoon, in ordinary fire; and the chapter on the Actual Assay of Coal for Commercial Purposes.

COBALT.

Fuse a borax bead in platinum wire, before the blow-pipe's flame; when this bead is cold and *colorless*, moisten it with water, and dip it into the pulverized sample of ore or substance to be tested; interfuse the ore and flux, before the oxidizing flame, to perfect fluidity; if a small quantity is present, it will show blue when hot and cold, in both oxidizing and reducing flames; if a larger quantity is present, the color will be thereby increased to, from blue to bluish black.*

If the glassy bead is too dark to be recognized, break and pulverize it, when this and other characteristic dark colors, may be seen much better than by the method of flattening the hot bead with pliers (the much more difficult and less efficacious manipulation described by authors).

It is, when reduced to metallic powder, magnetic, as iron and nickel are; but this blue bead with borax, together with its prompt oxidation, and difficult reduction to bright metal, distinguishes it most certainly from them.

When dissolved in nitric acid, it has from a pink to a port wine color, which is varied in shade by the quantity present.

COPPER.

The only red metal. A very delicate test for it, in all its mineral combinations and metallic alloys, is to heat a small piece of the sample, between the platinum tips of the forceps, before the blue flame for one minute; then moisten it with a drop of hydrochloric acid (muriatic), and after a few seconds for the acid's action, to re-apply it before this flame; if copper is present in the alloy, liquid, or mineral, the blue flame from chlorine will first appear, and then the characteristic green from copper.

First test the naked forceps in the flame, to know that no copper is produced from the relics of former trials; and also take particular care that the acid does not reach and extract the copper from the "German silver" handle of forceps.

It is a bad practice to make these testing handles with any metal or metallic alloy that may interfere with such tests.

A powder may be best examined on the platinum wire, when moistened with this acid into a paste, and treated otherwise as above, or on charcoal, or in an open fire.

If you have no acid, by simply dipping the ignited and well-roasted red-hot sample into oil, a tallow candle, or any other fat, and re-flaming it, the green color from copper can be more transiently but distinctly shown.

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* In all cases of colors of hot and cold beads, only *black* heat is alluded to.

To examine for copper in an open fire, pulverize about one ounce of the ore, then intimately mix it with half its weight of salt and one-fourth its weight of fat, into a somewhat moist mass, and cast it into a clear, open fire; if copper is present in practical quantity, the blue and green flames will be recognized.

Or any copper ore may be known by being first roasted in an iron spoon, or on iron; and, secondly, again roasted with salt; and, thirdly, by being placed in a clean vessel, with sufficient warm water to just cover it, when, after some time, a green solution will expose its presence.

The copper bead with borax is green, by the oxidizing flame, like chromic acid, but the reducing flame abstracts the color from copper only, by reduction to metal.

THE COMMERCIALLY VALUABLE ORES OF COPPER ARE THE YELLOW DOUBLE SULPHURET OF COPPER AND IRON, THE GRAY SULPHURETS, THE BLUE AND GREEN CARBONATES, AND THE BLACK AND RED OXIDES.

1. THE YELLOW SULPHURET (COPPER PYRITES)—Is more universally distributed than any other, and in the "true fissure veins" of Cornwall it is the prevailing copper ore, which has sustained the long-continued and enormous sales from that very small but exceedingly rich mining region.

It varies in composition, but may be placed at about 34.6 of copper, 30.5 of iron, and 34.9 of sulphur. Specific gravity from 4.16 to 4.3. Hardness from 3.5 to 4. It is generally of massive texture, and irregular, conchoidal fracture; of a color that varies from gold yellow to a *tarnished*, deep bronze yellow, with a thin oxidized surface coating of "peacock" ore, having iridescent mixtures of green, blue, and purple. These yellow and peacock hues distinguish it from the arseniuret and sulphurets of iron: it is also much softer than either; cuts crisply brittle, with less lustrous streak; takes a lower position under water treatment than gold; is dissolved by *either* of the *single* acids of *aqua regia* (nitric or muriatic), which gold resists, and does not look alike when viewed from all directions. It changes color before the flame of the blow-pipe, and thus promptly proves that it is not gold; yields a button of copper when fused with borax on charcoal, which, being red, is as eminently characteristic. When dissolved in acid, it deposits copper on clean iron or zinc, also known by its red color. If fused on naked charcoal, before blow-pipe, it becomes magnetic from its iron, and gives the reaction when tested for sulphur, by any of the methods given under that heading, as well as the more general one for copper.

2. The Gray Sulphuret of Copper—Varies from light metallic lead color to plumbago; cuts freely, but with less crispness than the yellow sulphuret. Its specific gravity is from 4.7 to 5.2. Hardness from 3 to 4.

Its composition varies greatly, both as regards the number of elements, and their respective quantities. The copper generally runs about 38.42, more or less ratioed with the following: Arsenic, 2.08; antimony, 25.27; iron, 1.52; sulphur, 25.03; silver, .83; zinc, 6.85. The arsenic, antimony, and zinc vary down to nothing; whilst the iron runs up to 7, and the silver sometimes appears to replace the copper, to upwards of 30 per cent., and it is frequently associated with even still more numerous, outside minerals, in a mechanical form.

The general copper test will inform you of its presence, and an actual silver assay, or especial approximate tests, should be always made from all such soft gray ores, which almost invariably contain it, in silver-bearing regions.

The tests for the other minerals may be made as directed under their separate headings.

3. The Blue Carbonate of Copper.—The blue carbonate of copper is generally found in small quantity and merely stains the surface of stones; it is composed (from a careful analysis made by R. Phillips) of the oxide of copper, 69.08; carbonic acid, 25.46; and water, 5.46. Specific gravity, 3.5 to 3.77. Hardness, from 3 to 4.

Its color is always of distinct, showy brightness, and varies from a somewhat deep blue to Prussian blue. In common with all carbonates, it effervesces in acids. It gives the general copper reactions, and when pulverized and mixed with salt, oil, and flour, will give the blue and green characteristic flames of chlorine and copper, when thrown into a hot fire.

4. **The Green Carbonate of Copper (Malachite)**—Is in every way, except color and composition, similarly detected.

R. Phillips gives its composition, 72.2 oxide of copper, 18.5 carbonic acid, 9.3 water.

Color, bright, strong green, to bright, pale green. Specific gravity (when solid), 3.5 to 4. Hardness, 3.5 to 4.

5. **The Black Oxide of Copper**—Like the carbonates, is invariably found above the water-line. It has a soot-like appearance, is friable, somewhat unctuous, and, like the black sulphuret of silver, soils the fingers.

It is also frequently seen in the shallow portions of Cornish lodes, although more in indication than quantity. It is more easily discriminated than the other coppers, as all that is necessary is to moisten the tips of your finger and thumb, to rub this mineral thereon, and quickly apply the moistened powder to your lighted candle, so as to recognize the characteristic green flame of copper. It is also most easily dissolved by acids and promptly reduced both by blow-pipe, and crucible. It will not stand the water treatments, by the small or large scale.

6. **The Red Oxide of Copper**—Is sometimes found in workable quantity, but is generally associated with the shallow carbonates, or ride a deeper development of gray ores.

It may be easily detected by the foregoing methods; and being of simple and rich composition—copper 88.5, and oxygen 11.5—it can be as readily assayed.

It will not stand against water-washings, without considerable wastage. Nitric acid gives a green solution with this ore, which deposits copper on iron or zinc when immersed therein, for a short time. Cinnabar, of carmine red, is insoluble, loses color, and freely volatilizes in fire. Red silver ore shows no color with nitric acid, and precipitates plenteous white curds with salt. Red ochre of iron gives no copper reactions, and remains as brick-red as ever after being strongly heated. (See silver, mercury and iron.)

There are still some fifty other ores of copper, which partake, more of scientific interest, than practical value; as they are not found in sufficient quantities to pay for separate extraction.

FELDSPAR.

There are four kinds of feldspar: common feldspar (orthoclase,) albite, labradorite, and nepheline. They almost entirely compose the porphyries, and are present in the various granites, as explained in Chapter I, Section I, in a crystallized condition, where they may be more advantageously studied; as also in mixed disintegrated aggregations, in fine-grained re-formed Azoic rocks, described in Chapter II, Section I; and also in lavas. The miner, not requiring a very close analysis of these spars beyond their visual recognition, I must save the considerable space that these would require for illustration, and refer the more inquisitive to those works that are particularly devoted for discrimination of all the minerals. For the miner's purpose, common feldspar (potash feldspar) is most beneficial, which he can study, with the aid of a good glass, in the granite folds of the book of Nature, sufficiently well for the purpose of recognition, so that he may distinguish it by appearance and inferior hardness from its more glass-like associate, quartz. (See Albite, at page 214, this chapter; and the Composition of Primitive Granite, Section I, Chapter I, at pages 21, 22.)

FLUOR SPAR.

In many of the older formations, fluor spar accompanies the minerals of copper and lead; it crystallizes in the cubical system, and varies in color from a watery white to yellow; from sky blue to greenish blue; and from pink to amethyst or dark purple, approaching to black. It is very brittle, does not scratch glass or crystallize, like quartz; and is not scratched by the nail. On being heated before the blow-pipe, or in any open fire, it may be seen to burst violently, with a crackling noise, into numerous pieces, with peculiarly phosphorescent lights, from blue to green as the mineral is composed, and which will continue for some time after they have escaped the fire. This last is a superior and ever ready test, as a stone can be cast, even in the sage-bush fire (which is better exhibited by night), and tested in a few minutes.

This appearance, once seen, will never be forgotten.

GOLD.

The only yellow metal, and it is found in the metallic state; or for practical purposes, it may be so considered.

It is more or less alloyed with silver and copper, and its color and value will always vary accordingly.

Pure gold is yellow, which color is unchanged by fire, or any one of the ordinary acids; it is however easily dissolved in nitro-hydro-chloric acid (called "aqua regia," which is composed of from two to four parts of hydro-chloric acid, added to one of nitric acid).

It is much more ductile than any metallic alloy of similar color and appearance, and flattens under pressure to an almost unlimited size, without cracking its edges. When a supposed gold button is recupelled with lead, it should not lessen its weight but to a very slight degree, or base minerals will have been present.

It is best known in the stone by always giving a steady yellow metallic lustre in all directions, or the same to the eye when the stone is turned round during observation, whether it is dry or wet. Other yellow minerals are lustrous in certain positions only, or vary in different directions, as they are more or less reflected from bright faces.

In the absence of other tools, a very efficient and ready test may be extemporized by taking a transparent wine or whisky bottle for a concentrator, into which place 1,000 grains of finely pulverized quartz; after the bottle is half-filled with water, securely corked, and well shaken, to sink the float gold and arouse the débris, the dirty water may be carefully poured away; repeat this half-filling, shaking, and pouring, until clear water passes out; next concentrate, by holding the bottle by the neck with the right hand, just as you would a horn, and allow the greater part of the lighter pulp to pass towards you through the neck, during suitable side oscillation, so as to observe, by looking up through the glass, if any gold lies under the residue. (See the chapter on the Gold Assay, for greater quantitative accuracy, by extended manipulations.)

In water treatment, it occupies the head, and resembles in appearance nothing closely but yellow copper, or mica; the heavier of these takes a lower position than gold, whilst the lighter may be washed entirely away; or yellow, bright brass chips, or spelter, which should not be there but by chance, and can be tested, by darkening, in fire, or may be thoroughly removed by acids. (See, also, Chapters III and V, Section III.)

If you have any doubt about its being gold, after these trials, it is not gold.*

GRANITE.

Granite proper is composed of quartz, feldspar, and mica; the last two only, are crystallized within the general mass of quartz.

When near to the eye it has the tri-colored speckled or spotted appearance of these minerals, but its distant general average and most common color, varies from dirty white to gray.

Many of the granites are sufficiently hard to polish, and an unusual variety called red granite, is extremely beautiful: Pompey's pillar in Alexandria in Egypt is made from, *one very compact stone*, of pinkish red granite; and it is still just as perfect as when first cut and polished. Syenite has hornblende in place of mica and is generally of a somewhat finer texture.

It is called syenitic granite, and is the kind found in the United States of America.

Examine each separate component part by the rules under their respective headings in this chapter, and refer back to page 21, Chapter I, Section I, for more comprehensive description.

GRAPHITE AND PLUMBAGO.

Graphite is composed of carbon, with from about one to three per cent. of iron, which varies its color and metallic lustre from that of polished platinum, to a dull lead gray. It is of a flaky appearance, easily scratched by the nail, perfectly infusible before the natural blow-pipe flame, and insoluble in all acids. The darker kinds resemble the less frequent molybdenite (sulphuret of molybdenum) in appearance; but the latter is known by the

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*An excellent practical detective for all these similarly colored shining mineral particles may be afforded with an agate or other clean pestle, by simply rubbing the wet residues from water concentrations; as the *minerals* will pulverize to still smaller grains, whilst *the little nuggets of gold and all other ductile metals*, will continue to flatten out into larger and much more lustrous and conspicuous scales.

sulphur test, lessening its weight before flame, and by partiall dissolving in nitric acid. Graphite is very much like nativ amalgam, and, when rubbed by gold, this metal is whitene thereby as if amalgamated; this may be wiped off, but canno be volatilized by the flame, like mercury.

Plumbago contains a greater and variable amount of iron, no exceeding ten per cent. Its quality is governed by this proportion, its freedom from earthy impurities, and more rigidly substantial homogeneous body.

It marks as the lead pencil, the superior article being quickl and completely erased by rubber; stands fire, without change o form, lustre, color or weight; and is but very slightly affected b acids.

HORNBLENDE.

This mineral is found, both crystallized and massive, as well as in syenitic granite; the hornblendic slates; hornblendic feldspar, which is the fine-grained rock called greenstone; and hornblendic albite, a somewhat similar rock denominated diorite; as well as in numerous other more complicated rocks, that do not in any way concern the miner. It may be regarded as a silicate of lime and magnesia, but contains various mixtures: about fifty per cent. of silica, with magnesia, lime, alumina, the protoxides of iron and manganese, hydro-fluoric acid and water, in consecutively diminishing quantities. Here the iron, as in mica, darkens the specimen. The chief difference is that mica contain potash, instead of lime and magnesia.

You should become familiar with its general features, whe dissected and exposed by a knife and lens, as seen in the granit named syenite; and illustrate on charcoal, in the blow-pipe's ho test flame, that hornblende fuses to a globule, that varies in co or from green to black; whilst mica, which may be taken fro granite proper, is thus not only infusible, but becomes opaqu and much whiter. Remember, also, that, though cleavable, it harder, more horn-like and tough, as well as being non-elasti and less glassy than mica.

Specific gravity from 3 to 3.4. Hardness from 5 to 6.

These are sufficient tests for your purposes of mining. (See numerous authors on general compositions of all the diversified minerals, for other combinations.)*

IRON.

Any mineral containing iron may be rendered magnetic by being placed upon charcoal within the reducing flame from the blow-pipe, for a few minutes.

For very delicate tests, it is best to take off the glass from a small pocket compass, and then, after securing the stone or slag in a *cloven stick* or some other *non-magnetic* forceps, it may be placed so as to almost touch the side of the needle.

When the powdered sample is mixed with borax in the platinum wire loop, and strongly heated upon charcoal within the reducing flame, it fuses to a bottle green bead.

If other, more easily reduced, minerals are present, the reducing flame will prevent their oxidation.

Iron differs from nickel, which is also rendered magnetic after fusion, by the borax bead of nickel being, instead of bottle-green, violet when hot, and reddish brown when cold.

It differs from cobalt by not showing the blue color, as produced by this mineral or metal, when fused with borax.

The rust water test for iron, described in the chapter for Practical Men's Discrimination, may be used, when a violet to reddish brown from nickel and manganese or the blue bead of cobalt appears, to see if iron is present, and also the carbonate of soda test for manganese.

Iron is difficult to reduce to metal, in a short time; whilst nickel and cobalt, with carbonate of soda, are easily and promptly reduced: the first to a white magnetic metal; the second to gray magnetic powder. Be careful that no iron has been abraded from an iron mortar; bruise in brass, or between stones, so as to avoid such a deceptive result.

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* In testing a sample for fusibility, you should select a sharp-edged piece, no larger than a pin's head, and place it in a recess of the charcoal, having only just sufficient size to retain it in secure position.

Hold the face of the coal almost square to nozzle of pipe, and then blow a *clean concentrated mixture* of the yellow and blue flames, upon the test, in such a manner as to distance and steady strength of blast, that the greatest possible heat may be produced, and then patiently wait for a thorough trial, before decision.

After fusion, it will be advisable to pulverize, so as to resort to the water treatment system, described at foot of page 186. which will pass off the soluble chemical portions of the flux, as well as the lighter mechanical débris; when the resulting metals may be dried over a tea-kettle, and further examined by magnet or magnifying glass.

THE COMMERCIALLY VALUABLE ORES FOR IRON ARE THE ARSENIURET, CARBONATE, CHROMATE, HEMATITES, SULPHURETS, AND THE MAGNETIC VARIETIES.

1. THE CARBONATE OF IRON—Free from other carbonates, is distinguished from the rest of the iron ores by nitric acid, which causes it to effervesce when in a pulverized condition. It dissolves slowly. It is, when pure, composed of protoxide of iron 62.07, carbonic acid 37.93; but, as it is often mixed with manganese, lime, magnesia, and alumina, as well as mechanically associated with quartz, little reliance can be placed on these figures for practical purposes.

Its specific gravity ranges from 3.6 to 3.85. Hardness from 3 to 4.6.

Generally massive and somewhat foliated, but at times crystallized in rhombohedrous and hexagonal prisms, occasionally with curved facets. Sometimes found in irregularly blistered, curvilinear forms commonly called "Kidney ore." Natural appearance sparry, vitreous, colored from yellow to gray, or from reddish brown to brown, which changes by exposure to black, on its surface. The streak and powder of the black variety is brown; that of the others, as themselves. It attracts a very delicate magnetic needle; blackens before the blow-pipe's flame; and, when intensely heated within its yellow flame, it becomes more magnetic, and is then attracted by an ordinary magnet.

2. CHROMATE OF IRON—May be distinguished from other iron ores by the emerald green color of its glass, when fused in wire, with borax, or phosphate of soda. This color is more easily obtained, and in both flames, by a very small quantity, than would be generally the case with iron which gives a bottle-green in the reduction flame only; when in excessive quantity, the glass of iron is reddish brown. The iron bead in the platinum wire, being

again fused with a very small piece of tin, becomes copperas green; the chromium bead being unaltered by tin. By taking the same small quantity of any other iron ore than the sulphuret (which requires longer time), and fusing it in a similar manner with borax, the beads may be more readily distinguished, and the presence of any chromated ore be established with greater certainty, by comparison.

Tungstate of iron also gives a green bead with borax, and it will be safer to have collateral proof by fusing with microcosmic salt, to see if the red bead is thus obtained from tungstic acid. See Tungstate of iron and Foot note at page 205.

When any chromic ore is mixed with about equal parts of carbonate of soda and nitre, and fused, either on clean iron or platinum foil, over the clear flame of any lamp, further intensified by upward blast of blow-pipe, a very small quantity can be detected by its forming an effervescing sulphur-yellow mass, both when hot and cold.

This may also be performed in an iron or platinum wire, before the blow-pipe's clear flame.

These colors are best compared after coarse pulverization.

If you have no better convenience, a piece of clean iron may be warmed in a hot fire to bright redness, and the intimate mixture of flux and ore sprinkled thereon, when, if it be a chromate, this yellow mass will as certainly follow.

A piece of small hoop iron, or crinoline steel, of about two feet long, may be conveniently used, by first dipping one end in water, then into the pulverized sample, intimately mixed with fluxes, and, after warming it to bright red in the fire, the color may be recognized, either at sight or when pulverized. This may also be performed on bone-ash cupel, before blow-pipe, or in a clear, hot fire; green patches may appear around the margin of the fused mass, where the soda has probably combined with the phosphorus from the phosphate of lime, and also produced the reaction of the phosphate of soda bead, as before explained.

The addition of nitre to carbonate of soda, although wonderfully effective for intensifying and creating a color where none would otherwise appear, when only a minute quantity is present, is not necessary for detecting the practically valuable ores, which the carbonate of soda would sufficiently expose. Long firing is required to destroy this yellow color.

It physically resembles some of the reddish brown or black hematite ores, excepting that it shows silky facets, which are also frequently conchoidal, and of a more earthy transverse fracture. When pure, it is unaffected in color before blow-pipe or in tube, but becomes magnetic. It is nearly always associated with lime, magnesia, or alumina. Specific gravity from 4.3 to 4.6. Hardness said to be 5.5. I have a fine sample now before me, which is not so heavy, being but 3.9; probably cellular; and its hardness does not exceed, in the fractured parts, 4.5. Composition irregular; generally contains about fifty per cent. of oxide of chromium, and thirty-five of the peroxide of iron; the remainder variously composed of lime, magnesia, and alumina.

Chromate of potash may be formed by fusing this mineral in a crucible, with caustic potash. This, dissolved in a small quantity of water, and filtered, is a mutual test for lead and itself, in acid solutions; which may be sometimes resorted to for positive proof of its presence.*

3. HEMATITE IRON ORE—Is from a red to a brown color, approaching to black on the faces of fracture, but not exposing much appearance of crystallization; scratches and bruises to a red powder, which, being very friable and somewhat unctuous, stains the fingers, and forms a red mechanical solution with water, that favors to a remarkable degree its separation from tin ores, with which it is frequently associated in Cornwall; and where it forms red rivers, which reach into and color the sea, for miles in extent.

Specific gravity from 3.5 to 4. Hardness, maximum, 5.5, varying downwards to as low as 3, according to the extent of disintegration, decomposition, etc. These ores generally produce about sixty per cent. of cast iron, and as high as sixty-four has been obtained, depending on gangue, etc. Blackens and becomes magnetic before the blow-pipe; does not effervesce in acids, as the carbonate; pulverizes to an impalpable red powder, which may be all passed away in suspension by water both before and after ignition, and gives, when enclosed in platinum wire with borax, in the yellow flame of the blow-pipe, a bottle-green glass; not the emerald greens of the chromate and tungstate of iron, last described.

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* I see no reason why the *commercially valuable chromates* cannot be made from these ores in the different districts of California, as this mineral is found in many places, where fuel is abundant, and the process of manufacture is not difficult. See second volume on Mining and Metallurgy.

It yields constitutional water, when heated in a close or open test tube, above the boiling point of water, to low redness. This must not be confounded with mechanical moisture; and therefore it should first be well dried in a clean basin, placed as a lid over a tea-kettle, or coffee-pot with boiling water (if you have nothing better). See *Water* in this chapter.

4. MAGNETIC IRON ORE (NATIVE MAGNET)—Is sufficiently characterized by its singularly inherent or naturally magnetic and polar powers, and by being iron-like black, in bulk, streak or powder.

It is a fine smelting ore, and is very generally found in large quantities throughout the world, in nearly all formations.

5. MAGNETIC IRON PYRITES (SULPHURET OF IRON).—It varies from yellow to copper and flesh color, and is generally found massive.

Composed of iron 60.5, and sulphur 39.5.

Large quantities of the darker varieties were taken from the Great Onslow Consols Mine, Cornwall, which often puzzled the miners, who were unaccustomed to separating it from copper by the light of the candle, before it was drawn to the surface. It tarnished by exposure so as to closely resemble the purple ores of copper, which, however, might have been facilitated by the presence of a natural solution of copper, that was so strong as to be profitably treated at the surface, by precipitation on metallic iron.

It cuts more freely with the knife than common iron pyrites, its hardness being from 3.2 to 4.4, and specific gravity from 4.4 to 4.6. It attracts the magnetic needle slightly, and fuses when completely enclosed by the yellow (reduction) flame, to a black globule, which is strongly attracted by the magnet: after it has been very much heated before the blue, oxidizing flame, it bruises very freely as red oxide of iron.

6. COMMON IRON PYRITES (BI-SULPHURET OF IRON)—Is of yellow color and metallic lustre, in mass and in powder; crystallizes generally in cubes, its modifications, and derivative shapes; but

sometimes it takes the place of other minerals' vacated forms, by filling such cavities; and also very irregularly massive or speckled through quartz veins, etc., etc.

Composed of 46.7 per cent. of iron, and 53.3 of sulphur; its specific gravity is from 4.8 to 5.1, which alone distinguishes it from the magnetic variety; its hardness is from 6 to 6.5. It strikes fire with steel, and scratches glass freely, which the magnetic iron pyrites will not do; and common iron pyrites will not affect the magnetic needle. It gives the various reactions for sulphur, and, heated before the blow-pipe on charcoal, it volatilizes sulphur, recognized by its smell; it affords a mass, or, if in very small quantity, under a perfect reducing flame, a black globule, which attracts the magnetic needle.

The sulphurets of iron are profitably worked for gold (which in all gold quartz regions, they invariably contain); in some cheap labor districts they also provide sulphur, by forming sulphate of iron, sulphuric acid, sulphur, etc.

7. Arsenical Iron Pyrites.—The Practical Analysis of Dr. Thomson, alluded to in the Elementary Treatise on Mineralogy, by William Phillips (to which work I am indebted for many others), gives 33.98 of iron, 45.74 of arsenic, and 19 of sulphur; the theoretical quantity being 33.57 iron, 45.53 arsenic, and 19.9 of sulphur. Specific gravity 5.7 to 6.3. Hardness 5.5 to 6.

It crystallizes in variously modified rhombic prisms, which, in practice, are seldom seen to further advantage than to show that the sharp angles are mostly turned outwards, forming aggregated groups which are very different to the sulphurets of iron. It is nearly white, unless tarnished to light yellow; of very bright metallic lustre, which, connected with its hardness, scratching glass, striking fire with steel, and garlic stink; separate it from the minerals that would otherwise too closely resemble it.

A small piece may be rendered magnetic by being placed on charcoal, and enclosed for some time in a steady and very hot reducing flame.

8. Tungstate of Iron (Wolfram).—Although of no commercial value, this obtrusive mineral is often a source of much annoyance to the tin miner; for, being non-volatile and of similar friability and weight, fire, pulverization and water, fail to effect

its separation : and, as the smelter requires the pure tin oxide the millman has to rid it from this stubborn gangue by actually dissolving it in hydro-chloric acid.

It is composed of 74.66 of tungstic acid, 17.59 protoxide of iron, 5.64 protoxide of manganese, and 2.1 of silica, from a comparatively pure specimen, as analyzed by Berzelius ; the silica being probably accidental. Specific gravity from 7.1 to 7.4. Hardness from 5 to 5.5. Its color varies from dark brown to black; the freshly fractured faces are always lighter, and the streak reddish brown.

Being of higher specific gravity, less volatility and friability, than any mineral which it resembles in color and general appearance, excepting tin, it may generally be recognized and separated by the water and roasting treatments; and when thus associated with tin it can be readily parted by being then dissolved in hydrochloric (muriatic) acid, and rewashed away. Tin oxide is insoluble in all acids.

It is found both massive and crystallized in rectangular prisms; whilst tin is mostly in quadrangular prisms, which are terminated by four-sided pyramids. It is readily fused with borax, yielding a green bead, which neither acts on the magnet, nor produces white oxide and metallic tin. Differing from most iron ores, it decrepitates like tin. With microcosmic salt, it yields a red bead. The most certain test is that of acid for the tin miner's guarantee against error, and for ascertaining the actual quantity of each mineral present, by difference of insoluble residue of tin oxide and total combined weight.

ITACOLUMITE.

A quartzose rock which is more or less laminated by mica, and sometimes so regularly parallel that it forms into a cleavable and flexible sandstone. It was named from the Brazilian mountain, "Itacolumi." It is a noteworthy fact that diamonds and other precious stones have been found in similar rocks, there and elsewhere; but the universal necessity for such has not been sufficiently well established for any very reliable, or general rule.

The micaceous quartz rocks are very rare, and I have never seen any, in all my journeys for examination throughout the United States of America.

British Columbia has a somewhat similar rock, in two distant districts, at Howe Sound and near Yale, where large scales or crystals of mica are deposited at varying angles in the quartz.

KAOLIN.

A peculiar clay, composed of silica, alumina, peroxide of iron, and water. It has been most successfully used by the Chinese, in the manufacture of the porcelain called "china," in which they have, from superior skill, better natural material and most excellent fire-proof colors, not only preceded, but surpassed all nations.

It is chiefly found in the hollows, lying on the flanks of granite hills, being the resultant residue from the washings of this rock, after natural decomposition and disintegration have released the potash and passed it away in water.

It is still found in greater abundance, and of better natural quality, in China, than elsewhere. Cornwall, France, and Saxony, are the principal European sources. It is found in several parts of Cornwall, of white, yellow and pink colors, and this kind of mining has recently become an extensive and somewhat profitable business.

The mode of extraction and preparation for the market is very simple, and consists of shovelling and stirring the broken masses in water, until the impalpable kaolin debris is suspended therein; it is then conducted into several suitably formed catch reservoirs, provided with flushets for shutting off the water when each pit is full, so that the clay may settle to the bottom; which operation is repeated, after the clear water has passed away, until the white mud becomes some six inches deep; when, after it is sufficiently dry, it is cut into cubes, further dried for the market by the summer's sun, and placed under sheds, to be shipped when convenient to the distant market.

As it is also the base of fire-resisting bricks, a very hot fire will to some extent, prove its quality. (See, also, Alumina.)

LEAD.

All the lead ores can be reduced, even on unfluxed charcoal; but much more readily with equal weight of carbonate of soda.

It deposits oxide upon the coal at about a half-inch from the test sample, which is orange-yellow when hot, and sulphur-yellow when cold. Bismuth deposits a very similar oxide, so that they are better known from the physical characters of their minerals and metals. Metallic lead is easily recognized by its well known color, manner of fusion, rainbow streaks when in fluidity before the oxidizing flame, the crystallization and color of its oxide on the ash, by its flattening to a very thin disk without fracturing the edges, and its toughness when cut or repeatedly bent. Metallic bismuth is brittle.

Lead may be dissolved in strong vinegar, or by dilute boiling nitric acid, (say water 1, acid 1;) and, when in these solutions, it is precipitated by dilute sulphuric acid as sulphate, or hydrochloric acid to chloride, and the latter cannot be dissolved or changed in any way by ammonia. These wet tests are entirely different to bismuth, mercury and silver; which see.

The minerals of lead, (both galena and the carbonate,) are also very different in color and appearance, under water treatment, to those of bismuth, which differences will greatly aid you in discriminating what are otherwise similar.

LIME.

This alkaline earth may be recognized, in all of its commercially valuable compounds, as follows:

First ascertain, by applying the blow-pipe's flame to a small piece, not larger than a pin's head, that it becomes unusually luminous on its sharp edges; that the flame is transiently bordered by pink (which may be shown more distinctly when moistened by hydro-chloric acid,) and if it is infusible, for these are some of its qualities; and if it has, after having been subjected to strong heat, the peculiar caustic taste and slacks in water like the burnt lime of commerce.

It differs from quartz, and all the flinty compounds, by being perfectly infusible with carbonate of soda, when subjected to intense heat on charcoal; the soda passes into the coal, and leaves the lime as perfectly shaped as before upon the surface; whilst quartz, and all the varieties of silicious stones, would be fused thereby to glass beads. The carbonate of magnesia is also thus infusible, becomes luminous, and caustic, but lacks this pink colored flame, does not slack in water, and gives brownish pink when strongly heated on charcoal with nitrate of cobalt solution. Lime and all other carbonates effervesce in strong acids. Lime sulphate may be detected by the test for sulphur, as well as by its peculiar action before heat, of immediately swelling to a flour-like white, and then crumbling into "Plaster Paris." (See Chapters IV, V and VI, on examinations by blow-pipe and ordinary testings, for practical men.) If you suspect that it may contain both lime and magnesia, test for magnesia. Quartz scratches glass; these do not.

MAGNESIA.

The best test for magnesia, when free from metallic oxides, (and, if it is not so, avail yourself of the water methods, fully described in Chapter III, for separation,) is that of first roasting the sample on charcoal, before the blow-pipe's blue flame, then moistening it with a drop of the nitrate of cobalt solution, and re-flaming at intense heat for a short time; after which, if magnesia is present, a brownish pink or flesh color will be the result, when the powder or stone becomes quite cold. Take particular notice that the sample was not thus colored by heat alone, after the first ignition, and that this change was really produced by the solution.

It is, like lime, in being infusible before the blow-pipe on charcoal, both *with* or without carbonate of soda, and its hard kinds are thus distinguished from quartz and all flinty stones, which, though infusible when alone, are quite fusible with carbonate of soda; so that, if a small piece of the former is mixed with carbonate of soda, and intensely heated on charcoal, the soda will sink into the coal, and leave the unaltered skeleton of magnesia on the surface; whilst quartz, and the other silicious stones, are thus fused into glass balls. It does not now slack in water, as lime; which see.

Dolomite, a mineral-yielding rock, composed of about equal parts of lime and magnesian carbonates, is so similar to some of the lime rocks, that the blow-pipe tests are scarcely sufficient for certainty, when the following wet test will be better for your purpose: Weigh one hundred grains of the pulverized sample, which place into a porcelain dish, basin, or teacup, with about twice its volume of sulphuric acid, and then carefully evaporate to less than half its bulk. This will decompose both of the carbonates; and the sulphate of lime, thus formed, being insoluble in this acid, will lie at the bottom of the vessel; while the sulphate of magnesia will remain in solution. After allowing it to settle, pour off, or filter, into another basin, and evaporate this sulphate of magnesia solution over the chimney of a common coal oil lamp, to dryness. The first may be well water-washed, dried over the tea-kettle, and weighed as sulphate of lime; and the second may be moistened with water, and recognized by the peculiarly disagreeable, bitter taste of Epsom salts. If no other earths or minerals were present, its quantity may also be ascertained by calculating, on the basis of equivalent numbers, founded on the quantity of lime from its corresponding carbonate, the proportionate remainder of the carbonate of magnesia. These crystals may *now* be tested, by blow-pipe, as before.

MANGANESE.

These ores are found (commercially valuable) as oxides, which are from reddish brown to black, varying from earthy to a dull resinous appearance, lacking metallic lustre, bruising and streaking, either the same or a lighter shade of the color. To the eye it more or less resembles some flinty compounds, tin ore, the friable garnet and spinel, some iron ores, and certain magnesian rocks. It is readily distinguished from the flints, tin stone, garnet, and spinel, by its inferior hardness, (not scratching glass,) and from all minerals by affording a surprisingly delicate characteristic greenish blue, when fused with carbonate of soda, either on platinum foil over a spirit lamp; in platinum or iron wire loop, before the oxidizing flame; or in an iron spoon over an open, clear fire; this is by far the best reaction, which may, however, be further corroborated by fusing it with borax in the same manner, when the hot glass will show from violet to amethyst, and the cold glass reddish violet, approaching to purple, which appears almost black when in excessive quantity.

An addition of a very small crystal of nitre increases the color, by more complete oxidation, when minute quantities are present; and pulverization of the bead exposes the thus modified and true color of the glass, when in excess, much easier and better than flattening with forceps, so often recommended. By completely enclosing the borax bead in the yellow flame, this color may be destroyed, by reduction of the metal. As nickel gives a too familiar bead with borax, this infallible carbonate of soda test is also necessary, for absolute certainty.

Manganese, when boiled with sulphuric acid, may be detected by adding litharge, which changes the solution to pink.

MERCURY.

Its principal ore is the sulphuret (cinnabar,) which is from a light to dark red, always pulverizing very easily, and more like a drug than mineral, to bright *carmine* red. Distinguished from the red iron ores by this, and by wholly or partially volatilizing on charcoal or on red-hot iron, and by losing its red color at a moderate heat, as it is more or less pure, instead of becoming red and magnetic under an intense heat, like iron ores; and from the red clays by this volatility, not adhering to the tongue, and the test of nitrate of cobalt solution for alumina; from red copcopper and red silver, by neither giving the green flame, nor metallic silver.

All the compounds of mercury, when fused with carbonate of soda, at a moderate heat, are decomposed and reduced to metallic vapor, which, arising in fumes, are speedily arrested and condensed by a slight decrease of temperature; so that if gold, or any other amalgamating cold metal, is placed therein, the white amalgam thus formed on its surface, readily proves the presence of mercury. This may be tested in a close glass tube, held over a spirit lamp or upon a piece of red-hot iron; when a small strip of gold may be amalgamated if placed in the fumes; or the cold tube may be rubbed with a stick of clean wood, an iron wire, or a glass rod, so that the bright mercury, by being thus scraped into ridges, may be more readily seen within the glass. This may be varied to suit your tools, as in an iron spoon, in a teacup, etc., etc., as described on pages 206 and 207, and any bright cold metal, that is susceptible of amalgamation, will then expose mercury upon its surface.

Cinnabar bruises very easily, giving to the water a bright and peculiar carmine red, which, by repeated pulverizations, passes all away with the water into the second vessel, and must be there estimated; whilst the lighter, less friable, gangue residues can be separated by being swept over the margin, as convenient. Native amalgam of mercury and silver may also be known by the amalgamated surface, which must not rub off with a wet finger, like that from graphite, but pass away by heat alone.

The red solution may either be filtered immediately, or allowed to settle, and then decanted.

The minerals that resemble cinnabar are generally very much harder, and may often be thus readily detected *

MICA.

This mineral is widely distributed. When associated with quartz and feldspar, it forms the dark, glassy constituent of the granites; and in more minute scales, the similar ingredient of mica schist, (metamorphosed crystallized slate); as well as in numerous other mixed formations from primitive elements, in the secondary rocks. It is generally colored by iron from light silver gray to brownish gray, or from olive green to black, but is sometimes golden yellow. The miner may study it sufficiently, in true granite, by the use of a sharp knife, a lens, and blowpipe; he will see that it is easily cloven into very thin scales, which are elastic, (hornblende being non-elastic); it is infusible, and whitens before blow-pipe, (hornblende is thus fused to a globule of from green to black color;) it is also softer than hornblende. Specific gravity 2.8 to 3. Hardness from 2 to 2.5.

Transparent plates of mica have been found in the United States of America, two or three feet in diameter.

The cleavage is parallel to the facets, and it crystallizes either rhombic or hexagonal. It differs from hornblende by having potash instead of the alkaline earths, lime and magnesia. Talc is more soapy, and its scales are not elastic. Gypsum bruises

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* It is indeed amusing to receive the many samples forwarded from all directions for assay, which no conscientious man could charge a customer for, without direct robbery.

No mineral has fooled prospectors more than cinnabar, (the ore of mercury,) and not, withstanding the far-fetched modes of books, nothing can be more promptly tested. as will be seen by referring to my new method by blow-pipe, in Section III, Chapter VI, at the foot of page 206. Those who are not the owners of a blow-pipe, may take any small tube, as a straw, or the *stem* of the *otherwise useless* and disgusting tobacco pipe, and blow a similar current of highly heated air upon the sample and cold metal, from the flame of a candle, for a few seconds, when a wet finger will prove the presence or absence of quicksilver.

white, is also whitened and crumbled into "Plaster Paris," by heat, and when fused with carbonate of soda, gives the sulphur reaction on silver.

If lithia is present (which is very unusual) the sample is slightly fusible, and shows the corresponding red flame from that alkali, during the early effects under intense heat.

MOLYBDENITE.

Sulphuret of molybdenum is of very similar appearance, softness, and color, to graphite and plumbago. It is, however, a rare mineral, and named here more to distinguish it therefrom than for profitable usefulness in itself.

Its general color is lead gray, and in this it is more constant, than graphite. It is partially soluble in nitric acid, leaving a gray residue. It is also more than *twice the specific gravity*, being about 4.6. It gives the *sulphur* reactions, and diminishes almost one-half its weight on being roasted. Graphite does neither; which see.

NICKEL.

This metal is mostly obtained from arsenical nickel, called "copper nickel," its color being a lustrous pale copper red, with a somewhat darker streak and powder. When water-washed, its high specific gravity of about 7.5 favors its examination and estimation, which is further facilitated by its peculiar appearance and speedy reduction to magnetic metallic scales, with carbonate of soda on charcoal; but unlike antimony, zinc, tin, lead, or bismuth, it is not coated with white or yellow oxides. It may be otherwise detected, better by its differences with those metals that are also reduced to their magnetic actions, as iron, manganese, and cobalt. In common with iron and cobalt, it is magnetic; but the color of the borax bead with nickel being reddish brown in oxidizing flame, that of iron bottle-green, and cobalt blue, are sufficient with these. Manganese very often contains iron, which gives the magnetic action to the sample, the color at the same time being, with borax, too similar to nickel; so that the collateral tests by carbonate of soda, both for the greenish-blue bead from the manganese and reduction to the magnetic scales of metallic nickel on charcoal, must be resorted to, for greater surety. The fused slag, for the latter test, should be finely pulverized and examined by the water concentration and pestle method, fully described at page 186, under fire and water treatments.

The largest nickel deposit known is near the gap, in Lancaster county, Pennsylvania. Nickel was discovered there about the year 1856. This ore has a gray color, and is very heavy and hard; it is broken into small fragments, put into kilns holding about eighty tons each, subjected to heat produced by the burning of a small quantity of wood, and the expelled gas. It is then fused in a smelting furnace, similar to iron ore. The product from this treatment is reduced to powder between iron rollers, and shipped to Camden, New Jersey, where a complete separation is made of the nickel from copper and other metals.

The author is an agent for buying nickel and cobalt ores for shipment to a large *English* firm.

PETROLEUM.

Petroleum is an oil-like liquid, of from pale yellow to reddish brown color, somewhat lighter than water, and which is more or less found in, or flowing from, natural wells, in all countries, but more particularly in and around large or small coal fields. It has naturally a somewhat disagreeable bituminous odor; it is inflammable, and, during combustion, emits a thick black smoke. The black residue being weighed, gives the quantity of uninflammable matter present, and its comparative quality; which residue, on being heated to redness in a clean vessel, further exposes the kind and quantity of the non-gaseous, inorganic remainder.

Its composition varies from accidental ingredients; but it is essentially a hydro-carbon. By distillation, it produces naptha, a colorless or slightly yellow liquid that floats on water, composed of carbon 82.2, and hydrogen 14.8, this, by exposure to air and light, thickens, and again becomes brown petroleum; which latter, by further exposure, and oxidation, forms elastic bitumen, and compact bitumen, of specific gravity from 1 to 1.6, and earthy bitumen or asphaltum, when earths, etc., are accidentally mixed therewith.

Good practical tests are, boiling the sample in water, to ascertain if it will separate and float on the surface; careful ignition, for quantity and quality of flame ; and subsequent red heat of residue, when an approximate value may be promptly known, by comparative residual percentage.

TEST FOR GOOD PETROLEUM.—The color should be white or light yellow, with blue reflection; dark yellow indicates imperfect purification, or adulteration with inferior oil. The odor should be faint and not disagreeable. The specific gravity at 60° Fah. ought not to be below 0.79, or above 0.84. When mixed with an equal volume of sulphuric acid, the color should become lighter and not darker.

Great care should be taken to ascertain its quality, when procured from mine or store, before using it in lamps, and the following simple test will be sufficient to guarantee safety:

Pour a few drops into an open saucer and apply a lighted match thereto; if it light up like alcohol into a flame, it *should not* be used in lamps.

If you cannot light it in this manner, it is a non-explosive and safe burning oil.

PLATINUM.

A white metal which is always found in the metallic state; it accompanies gold in alluvial deposits, but is never found in veins.

Some authors have incorrectly written "*ores of platinum,*" but the metal is only *mechanically* mixed in gravel or sand, and not in chemical or constitutional form.

Similar in texture and appearance to nickel and malleable iron, but just somewhat more silver-like than the latter, it is not attracted by the magnet, and is thus distinguished from both of them. Insoluble in sulphuric, nitric, or hydro-chloric acids, when only one acid is used, which separate it from all the base white metals and their alloys. It is soluble in aqua regia, (which is composed of one part nitric acid, and from one to four of hydro-chloric acid,) and again precipitated yellow by potash or ammonia; chloride of ammonia (sal ammoniac) also precipitates it yellow, which can be reduced to spongy platinum by heat.

This metal is infusible by the ordinary heat produced in furnace or before the blow-pipe, both with and without fluxes; but it can be readily fused in the oxy-hydrogen blow-pipe flame.

Platinum is frequently *alloyed* with gold, silver, &c., and al- ntains traces of one or more of the metals of its own character, as "Iridium," (the most infusible, heaviest and hardest of all metals, specific gravity from 23 to 26,) "Osmium," "Palladium," and "Rhodium;" the last of which is also very hard, but brittle and almost insoluble.

Although these last named metals are very interesting to scientists, they are too sparsely distributed for profitable extraction by miners.*

PRECIOUS STONES.

THE DIAMOND—(which is pure carbon)—may be considered to stand foremost among the commercially valuable gems. It is transparent and colorless, or variously colored, and consequently less transparent; as yellow, blue, green, rose, brown, and very rarely black.

It is the hardest of all gems, 10; specific gravity from 3.48 to 3.55; and always found crystallized in octahedrons, dodecahedrons, and corresponding additional facets, which nearly always differ from other gems by being slightly convex. Where the edges of the crystal are imperfect, a lens shows that they have been more broken than worn off.

Diamonds are frequently coated with adhesive earths, and the forms and full brilliancy of their crystals cannot be seen until they are thoroughly cleaned.

It may be best known by its scratching the hardest flint, and all other gems; by being infusible, and unchanged (within any reasonable time) before the blow-pipe, even with fluxes, (quartz and silicates being more or less fusible with carbonate of soda;) by being insoluble in all acids, (even hydro-fluoric, which readily attacks quartz and silicates;) by its specific gravity; brilliant reflections of light; and becoming electric in its natural condition, when rubbed on cloth, as shown by its attracting small pieces of paper or other suitable substance, (which no other gem will do before it has been polished by artificial means.) It is mostly found in alluvial washings, in similar positions to gold, platinum, etc.

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* These facts of platinum being entirely absent from veins and almost constantly alloyed with more or less gold when taken from alluvial formations, serve to favor my opinion expressed at page 58, that much of the gold of gravel deposits was not originally deposited in quartz veins.

If the crystal is clean and its sparkle brilliantly clear, it may be tested by dipping in water; as the light from spurious paste or rock, will be extinguished; whilst the true gem will almost retain its full lustre.

If the *crystal* is like that of the diamond, a hand saw file will not injure the real gem, but will mark and mar the inferior stones.

This latter is a good and very practical diamond test for all natural stones.

Emerald (Beryl)—Crystallizes in long hexagonal prisms, with singular terminations (but not mitred from side facets, as quartz). Color, green; *beryl* being sometimes from blue to yellow; lustre vitreous; from transparent to translucent and opaque. Hardness from 7.5 to 8. Specific gravity, 2.65 to 2.75. Brittle, with conchoidal (irregular or flintlike) fracture. The transparent kinds, when in small pieces, become clouded before the flame of the blow-pipe, and with increased, continued heat, assume mother-of-pearl appearances.

Dr. Thompson gives their composition as 2 atoms tersilicate of alumina, and 1 atom tersilicate of glucina; the former is colored by the oxide of chromium, and the latter by the oxide of iron.

It differs from green tourmaline in hardness and crystallization, and from euclase and topaz by its uneven fracture, they having more regular cleavage.

Precious or Noble Opal — Is a beautiful, milk-colored gem, that also exhibits, in the light of day, a changing interior play of the pearl-like colors, green, blue, yellow, and red, which become yellow by transmitted light, and are sufficient in themselves for the recognition of this peculiar stone.

It is composed of soluble silica, and a varying quantity of water: sometimes as much as ten or twelve per cent.

Its specific gravity is about 2.2, but varies with the quantity of water present. Hardness from 5.5 to 6.5.

It is not so hard as quartz. It is infusible when alone on charcoal, before blow-pipe, but fuses with effervescence, in carbonate of soda, to a clear bead. It may be dissolved in boiling hydrate of potassa, and precipitated therefrom by sal ammoniac. Gives off steam, when heated in glass tube or before the blow-
ich may be condensed to water and arrested upon the
e glass tube.

SAPPHIRE (CORUNDUM).—This gem, when perfectly white, seems to be pure alumina (aluminum 53.29, oxygen 46.71). It, however, consists of two precious varieties, the sapphire proper, and the oriental ruby. The former has a specific gravity of from 3.9 to 3.97; the latter of somewhat less. There is also a common corundum, and ordinary emery.

William Phillips gives this paragraph's concise definition of the whole family: "Sapphire has obtained several names, dependent on its color and lustre: the transparent or translucent, *white sapphire;* the blue, *oriental sapphire;* the red, *oriental ruby;* the yellow, *oriental topaz;* the green, *oriental emerald;* violet, *oriental amethyst;* the greenish blue, *oriental aqua-marine;* with pearly reflections, the *chatoyant* or *opalescent* sapphire; when transparent, and with a pale reddish or bluish reflection, *girasal sapphire.* Some, when cut *en cabochon*, present a silvery, star-like opalescence of six rays, in a direction perpendicular to the axis; this variety is termed *Asteria.* The same crystal occasionally exhibits the union of two or three of these different colors."

It occurs in variously terminated six-sided prisms, and stands at 9 (being next to the diamond) in the scale of hardness. It is unaltered, even when in powder, before the blow-pipe's flame, on naked charcoal; but, when fluxed with borax, it fuses with difficulty into a colorless glass. It is unaffected by acids. Transparent pieces, *when artificially polished,* become electric by friction, and retain this property for some time. It may be distinguished from the diamond and zircon by specific gravity, crystallization, hardness, and fusibility; which see.

The oriental ruby is most beautiful and valuable. It varies from a rose to a blood-red color, of similar crystallization, and possesses the other features enumerated. In addition to these, it becomes green when highly heated, and returns to its original color when cold. The green sapphire is unchanged by fire.

Corundum stone and emery are of but ordinary beauty, and low commercial value.

TOPAZ—Is a stone of inferior hardness (8) to all the preceding, excepting opal, and of specific gravity from 3.49 to 3.56. Color either pale yellow, or various light tints of blue, green, or red. Lustre vitreous. Streak white. Not affected by acids. Infusible without flux, but with borax it slowly melts into a transparent glass. Occurs massive, rounded, and in right rhombic prisms, in primitive rock. It becomes electric and polarized after it has been heated to redness, and retains shape and transparency; whilst tourmaline, which also becomes electric, whitens, and swells; but its specific gravity is from 3 to 3.1. Its bright transverse fracture is also a distinguishing feature, against the otherwise similar minerals. Tourmaline is almost invariably corrugated lengthwise on its facets, and breaks transversely, with a resin-like and irregular granular fracture, which is frequently speckled with different shades of color, as seen through a lens.

The pale yellow topazes from Saxony are not rendered electric by heat, and some Brazilian topazes are changed to red when placed in the fire.

Topaz is composed of alumina 58.38, silica 34.01, fluoric acid 7.79, from an analysis by Berzelius.

TURQUOIS—Is a beautiful stone, that varies in color from apple green to sky blue; it is somewhat similar to malachite in mode of occurrence, texture, fracture, and general appearance, and differs from silicate of copper in fusibility and solubility. It may be easily known from the former by being more gritty between the teeth, and from the latter by changing to brown when enclosed and strongly heated in the reducing flame for a few minutes, as the silicate would thus become speckled with white patches.

It loses its color in hydrochloric acid (muriatic), but does not effervesce like malachite; it is also much lighter and softer, its gravity varying from 2.6 to 3 (malachite being 3.5 to 4.5), and its hardness from 5 to 6 (malachite varying from 3.5 to 4).

The residue from acid, after being well washed with water, gives the alumina reaction with nitrate of cobalt. (See Alumina.) Silicate of copper merely becomes white.

Turquois also gives much constitutional water when heated to low redness in a thin glass tube over a clean flame or hot iron, which, with its coloring element, copper, (detected by hydrochloric acid and blow-pipe's flame,) serve to separate it from other preceding gems.

It is composed of alumina 44.5, phosphoric acid 30.9, oxide of [illegible] 3.75, oxide of iron 1.8, water 19=99.95.

Zircon (**Silicate of Zirconia**).—This stone crystallizes very like the diamond to a flat octahedron, with its angles variously replaced. In this, and in the resin-like color, which also streaks white, it closely resembles the oxide of tin.

Composition, zirconia 67.16, silica 33.48.

It is not of great value as a gem; but it is necessary to be enabled to distinguish it, and more particularly from the diamond. When heated in a close vessel, with lime, zircons become pale yellow, and are then fraudulently passed as diamonds.

Its specific gravity is from 4.5 to 4.7. Hardness 7.5. Like the diamond, it is exceedingly infusible before the blow-pipe, merely losing color; but, *unlike the diamond, it may be fused with borax* to a transparent glass, and strong hydrochloric acid etches a mark on its surface. Tin oxide yields a yellowish white oxide on charcoal, which is deposited close around the sample, and is reduced to metal by cyanide of potassium, and, being much heavier, is readily distinguished by *comparative* water treatment. Its specific gravity is also *greater than the diamond and all other gems* (the diamond being but 3.55).

The first examination of a gem so as to approach to the true stone, may be for specific gravity, which will prevent many random trials by telling you what it cannot be, as just seen by the above example.

QUARTZ (SILICA).

Quartz may be distinguished from other *vein stones* by its insolubility in all acids, except hydro-fluoric and its hexangular crystallization; by freely scratching glass; infusibility and unchangeableness on charcoal, without flux; and by its prompt fusibility, with effervescence, to a clear glass, when fluxed by carbonate of soda. (See Discrimination of Vein-stones, pages 177 and 187.)

Although it is generally white, it has many shades of color, and enters into various flinty combinations.

It pulverizes more harshly and slowly under the pestle than any other matrix or vein-stone, particularly displayed by comparison, after having been roasted.

QUARTZITE.

A distinctly granular, quartzose rock, which appears as if a siliceous sandstone had been solidified by some means into a tough and compact formation. It is frequently found in more or less tilted dikes, having various degrees of cementation and hardness, but being less translucent and much more dirty than quartz.

Color from a dull and dirty yellowish white to gray and rusty gray. Does not expose any six-sided crystals, or similarly crystallized cavities so frequently seen in quartz, nor enclose perfect crystals of other minerals, within itself; although profitable veins of quartz are often found lying beside such dikes.

SILVER.

A globule of silver when placed, for a few seconds, on a clean bone ash cupel, before the blow-pipe's blue flame, should show no oxide from base metals, on the white ash. A button, that has been entirely freed from the base metals, will, by a kind of *minute* volcanic action, during rapid cooling in cold air, exude or build up warty protuberances, that indicate pure silver; this effect may, however, be lessened by slower refrigeration. Silver will deposit a red oxide upon the ash, if the oxidizing flame is too long continued.

It requires a considerable ratio of gold to prevent this exudation of silver.*

The frosty white silver globule flattens much harder than lead, but also with perfect edge to a thin disk. It is dissolved in boiling nitric acid, without residue, and is again precipitated by hydro-chloric acid, common salt, and all other soluble chlorides, which will either render the solution milky, or precipitate a white chloride, as less or more silver is present.

These chlorides are insoluble in acids, in common with those of lead and mercury; but the chloride of silver being completely soluble in ammonia, whilst mercury is only blackened and lead unchanged, must be employed for further discrimination after such precipitations. (See sulphur and soda tests, and Chapter VI, Section III.) There are many other tests, but these are most practical and reliable. See test by blow-pipe, page 208.

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*Many writers on metallurgy have stated that these effects are produced by escaping oxygen, for the reason that hot and molten silver, by having strong affinity for that gas unites with it, until a certain reduction of temperature causes it to depart thus suddenly to form such prominences.

This cannot be correct, as a red-hot match is neither rekindled nor even brightened in the least degree by the escaping gas.

The effect is, however, evidently produced by gas, as the eruptions are accompanied by a *hissing sound* that may be distinctly heard when the ear is placed *sufficiently close*.

I think they are caused by *nitrogen* gas.

Bright silver tarnishes to brownish yellow when placed into the yolk of a boiled or fried egg whilst still hot, from its affinity for the sulphur which it contains.

SLATE.

The slates have been produced from the water-washed disintegrations of the primitive mountains; first simply deposited as mud, then hardened and stratified by time and pressure. See Chapter II, Section I.

There are several slates, as mica slate, hornblende slate, clay slate or argillaceous shale, bituminous shale, plumbago schist, talcose slate, chloritic slate, and Cornish killas. The words used have explained all but the last, which is a peculiarly aluminous, highly metamorphosed and disjointed partially decomposed stone.

The slates have some resemblance to trap and blue limestone, but differ from both by having distinct laminations and cleavage.

Talcose slate has a soaplike feel; trap and limestone are more granular and rough.

All the slates have cleavage lines, and fracture in planes, but trap breaks to irregular conchoidal surfaces.

Trap rings to the hammer, more than slate or limestone.

Carbonate of lime effervesces in acids, and after strong heat, becomes caustic to the taste, and slacks in water.

SOAPSTONE (STEATITE).

Similar in chemical composition to talc (silicate of magnesia), but is more compact and slate-like in texture. It is generally nearly white, more or less colored by green or bluish green. When first excavated, it feels very soapy; but, on being exposed to a strong heat, it becomes less unctuous.

It is a good fire-stone, and, as it is easily wrought into shape, it becomes serviceable for smelting purposes.

It gives the magnesian reaction with cobalt solution, when carefully conducted. Differs from chlorite by being of lighter shade of green, and after being first powdered and dried over boiling water, by yielding no constitutional water when heated in a glass tube over alcohol lamp, at a red temperature; chlorite coating the cold upper part of the interior of tube with globules of water from condensed steam.

SODIUM.

This alkali is generally found in carbonate or chloride of sodium, which are both soluble in water, giving alkaline reactions, known by their peculiar tastes, and by coloring the flame strongly yellow; the carbonate effervesces, even in weak acids, such as are generally found about, as acetic (vinegar), citric, tartaric, etc. The manganese bead therewith, of greenish blue, is a mutual test for both manganese and carbonate of soda.

It may also be proven by the iron spoon test for sulphur, after mixing it with a known sulphuret or the end of a sulphur match, pulverized therewith, kneaded into a paste, then fused on coal or in the spoon, and placed on a moistened silver coin; this brownish black stain being, of course, a test for both. The common salt, after having given the yellow flame, may be tested in the manners described for chlorine, or by nitrate of silver solution. (See Silver.) Also, when in crystals, as side-proofs, by decrepitation and taste.

SULPHUR.

The most convenient test for sulphur is by roasting, and smelling the sulphurous fumes evolved during either of the methods described in the chapters on discrimination.

The best test is that of forming a soluble sulphate, by fusing with carbonate of soda on charcoal, before blow-pipe's flame, or in an iron plate or spoon placed in an open fire, and then on a moistened silver coin. The smallest quantity when thus treated, by staining the coin from light brown to brownish black, reveals its presence.

This is facilitated by first dipping the silver coin in boiling water, or warming it over a hot iron or a clear flame from a lamp, as this slight additional temperature greatly increases the affinity of sulphur for silver. (See chapters on discrimination by blowpipe, and by more ordinary facilities in the new methods for practical men.)

TALC (SILICATE OF MAGNESIA).

The talcose rocks have an unctuous or soapy feeling, and they vary in color from white to green; pure talc has an unusually pear-like lustre. It differs from mica, in being non-elastic; its leaves are, however, flexible, and so soft that they may be scratched by the nail.

It frequently occurs in a divergent, foliated, specimen form; but its valuable properties for the miner are more particularly displayed by its general dissemination in the talcose slates of the gold fields. In California, it is also found more or less pure, in massive beds and dikes; the exterior faces of fracture being conchoidal, of pearly smoothness, and in numerous variegated shades, from white to green, on the same face or stone. Those, being of a mixed composition, are generally much harder.

Impalpably fine mechanically suspended talc frequently accompanies chlorite and clay on the walls of mineral veins, when they traverse talcose clay slates, and is regarded as an equally favorable indication, as explained in Section I, Chapters VII, VIII, and IX.

TELLURIUM.

This grayish-white mineral is sometimes found in natural metallic condition. It burns green, and almost entirely volatilizes as a dense white vapor, before the blow-pipe's blue flame, which deposits its yellowish white oxide on charcoal; this oxide, being reheated where it lies, before the blue flame from blow-pipe, again passes away with a peculiar green flame. These volatilizations of metal and ores can only be effected at a higher temperature than metallic and mineral antimony, arsenic, sulphur, and bismuth.

Its ores are those of graphic tellurium, yellow tellurium, and black tellurium.

The first of which, from an analysis by Klaproth, yielded, of tellurium 60, gold 30, and silver 10. It has been found in small quantities in the quartz veins of Offenbanya and Nagyag, Transylvania; and in very much larger quantity at Carson Hill, Calaveras County, California, where it occurs in the veins of the New Melones Gold and Silver Mining Company. This Californian ore of tellurium is mostly graphic, but sometimes black tellurium is intermingled. It is of a more or less tarnished steel-gray color. Its specific gravity is about 5.7, and it ranges in hardness from 1.5 to 2.

The second (yellow tellurium), from an analysis of the same authority, is composed of tellurium 44.75, gold 26.75, lead 19.50, silver 8.50, and sulphur .5; the latter being accidental, it stands, by Berzelian formula, as telluret of gold, lead, and silver.

The third (black tellurium), from four examinations made by Klaproth, Brandes, Berthier, and G. Rose (where the two first only approach to similarity of analysis), the quantity of tellurium varies from 13 to 38.37, the lead from 60 to 85 per cent., the gold from 0 to 6, the silver from 0 to 1.28, copper from 0 to 1.3, antimony from 0 to 4.5, and sulphur from 0 to 11.7. Such differences but serve to show that the samples were either not well selected, or were of unsettled constitutional forms, and that most of the other minerals merely happened to be present. The last analysis, of G. Rose, gave 38.37 of tellurium, 60.85 of lead, and a probably chance quantity of 1.28 silver; thus placing it as a bi-telluret of lead. Therefore, its specific gravity is in this pure state 8.16, and its color tin-white; but, as may be supposed, its specific gravity varies down to 7, and its color to very dark lead gray and iron black, as varied by the presence of black tellurium and the other minerals. Its hardness varies from 1 to 1.5.

These ores are valuable for the precious metals they contain, and may be recognized by—

1. Their dense white fumes at high temperature, the green color produced before the blue flame when its white, or, if lead is present, brownish yellow oxide, is re-flamed.

2. The white oxide deposited in the upper end of a close glass tube, when the mineral is subjected to a heat that almost melts the glass (being much higher than arsenic, bismuth, sulphur, antimony, or mercury); which, on being re-heated in this state and position, either quietly fuses to colorless globules or minute orbicular patches. It evolves no smell, unless selenium, sulphur, or arsenic is also present.

3. Each kind may be separated by a lead assay with carbonate of soda (1 part of ore to 3 parts of the carbonate), and subsequent cupellation, which informs you whether it be a telluret of *gold and silver*, *without lead;* a telluret of *gold, silver, and lead;* or the bi-telluret of *lead alone*, as well as the ratios or quantities of each metal.

Tellurium may also be detected, in all its combinations, by first fusing a finely pulverized, intimate mixture of the ore with half its volume of carbonate of soda and charcoal, at a full red heat, in a close-ended tube; and then, after it becomes quite cold, to dissolve the telluride of sodium thus formed, in a few drops of hot water; when, if the substance contained tellurium, this water will be colored from a more or less dark amethyst to purple, according to the quantity present in the ore. An old tea-cup, crucible, or clean iron spoon, may be used for this purpose, if you have no *test tube.*

TIN

Is invariably obtained from its oxide, which may be known by various fire, water, and acid tests, much better and easier than by any of its physical characters.

First concentrate in a porcelain dish, cup, saucer, plate, or basin, or on a Cornish vanning shovel, in a horn, prospector's pan, or Mexican batea, and notice its head position, and peculiar resistance to the water's sway; its color when pulverized, which varies from almost white to dark brown, through all the shades of resin; and its remarkable roughness under the finger after this concentration. If quartz and some other mineral, of about 5 or 6 specific gravity, and of different appearance, are not present, it may be well to add them, for the sake of comparing the superior specific gravity of the tin oxide.

Knowing by this means that a mineral is present that thus far resembles tin ore, next roast at a low red heat, in an iron spoon, ladle, scorifier, or crucible, for half an hour, stirring the while with a small wire. After it becomes cold, pulverize to an impalpable powder, and rewash until the water ceases to pass off red, (caused by oxide of iron, which bruises away in water,) and the residue looks resinous and entirely free from other matter.

Unless the rare tungstate of iron is present—which must be dissolved in hydro-chloric acid—this residue is tin oxide. The oxide of tin may be distinguished and separated from all the irons, after being roasted at a low red heat, by being insoluble in aqua regia; the iron, being soluble, passes away in the liquor. Garnet and spinel, when powdered as well as in the stone, apart from crystallization, and the "precious stone, zircon," which also crystallizes in similar form, closely resemble tin stone; but these would have passed away in the water, over the margin with the quartz; therefore, a resin-like stone, that is unaffected by red heat, the pestle, water, and acids, is the oxide of tin; which may be still further proven by nitrate of cobalt solution, producing a bluish green on charcoal; zinc, being thus treated, showing green; but this ore would not be present after these concentrations by roasting, acid and water.

Metallic tin, when bent in close proximity to the ear, makes a crackling noise. (See zinc.)

TRAP.

Trap is a heavy and tough igneous rock, which rings under the hammer and breaks into irregularly shaped blocks with conchoidal and more or less granular facets. Specific gravity 2.8 to 3. There are several kinds of trap, as "Amygdaloid," with almond-shaped fillings of other minerals; "Porphyritic trap," &c., speckled with crystals of feldspar: "Basalt" is a very similar rock, which is more frequently found in columnar forms. The traps vary in color from greenish gray to dark brown; they sometimes lie in massive horizontal beds, but more frequently in dikes.

There are many other varieties of unimportant volcanic rocks.

WATER.

This liquid plays many important affinities in mineral formations, and therefore it is necessary for you to know how to ascertain its presence, when in chemical or constitutional forms.

First thoroughly dry the powdered sample very slowly and carefully at a heat not exceeding 212°, and then place it at the bottom of a close-ended test tube held in diagonal position over an alcohol lamp, and quickly raise it to a low red heat. If the mineral contained water, its vapor would be condensed upon the upper part of the glass tube.

For the many and very interesting peculiarities of water, see Chapter II, Section I.

ZINC.

The oxide produced before the oxidizing flame, when a sample is heated on charcoal, is yellow when hot, and white when cold ı stone of zinc ore is calcined in an open fire, its copious white ıes will arise and coat cold substances with white oxide, which, ng warmed, becomes yellow.

The oxide of zinc thus produced on charcoal, when moistened h nitrate of cobalt and re-flamed, forms perfectly green and re extensive patches than the tin oxide, which is bluish green, der to obtain, more capricious in shape, and less generally seminated; the oxide of tin is not only white both when hot and d, but it also forms close to and sometimes upon the assay piece. Zinc ores are more difficult in reduction than tin. It has a ıvy, non-lustrous hue, and, unless rolled into a thin sheet, very brittle. It is dissolved so rapidly by hydro-chloric acid, ıt the disengaged hydrogen gas-bubbles overflow the test tube, ich is quite different to the sluggish action of tin. Its ores ll not, like those of tin, resist water, pestle, fire and acids.* †

ADDENDA.

It will be well to bear the following leading modes in mind, as ey have greatly assisted in the discrimination of the useful elents enumerated in this chapter: First, the reactions before w-pipe, as comparative luminosity and fusibility; magnetic ce created; oxidation to known colors, or reductions to metal; lors produced by flames and beads in wire with fluxes or with trate of cobalt upon charcoal; peculiar odor of fumes; amalgaıting gold, &c., by mercury; and the fusion to sulphate of soda : the sulphur test on silver. Also, the collateral facts of hardss, colors of powder and streak, cleavage and peculiar fracture; ısticity, pliability, ductility, feel by fingers and teeth, taste and pearance; roasting and acids, salt and ammonia, &c.; and someıes crystallization, and specific gravity by weighing or water atment. After knowing what metallic mineral is present, you ll then be enabled to really assay it by the directions given in e following chapters on assaying.

It has appeared from this chapter, that both specific gravity and hardness may be most servient directors for the recognition of minerals, when they are in states of purity, many are ;) but, when mixed or impure, they must not be employed.

'ou will, after a little practice, become more and more attached to the ever convenient l costless mode, of comparison of specific gravities by *water* treatment.

It has been seen that the very numerous and too scientifically ridiculous terminations *ite* have been almost entirely excluded from this chapter, and book; as I could not see at earthly good could have resulted from their more general insertion, as such nonsenal surplusages are nothing better than retarding brakes to both practical 'and scientific gress. For example, "*Cassiterite*" for oxide of tin.

The following Tables are from Scribner's Mechanics' Companion.

TABLE OF SPECIFIC GRAVITIES.

Divide the Specific Gravity by 16, and the quotient is the weight of a cubic foot in lbs.*	Specific Gravity.	Weight of a cub. foot in	W't of a cub. in. in	W't of cub. in.
METALS.		LBS.	OZ.	LBS.
Antimony	6.712	419.50	3.883	.244
Arsenic	5.763	360.19	3.335	.208
Bismuth	9.823	614.00	5.684	.355
Brass, common	7.820	489.	4.525	.282
Bronze, gun metal	8.700	543.75	5.034	.315
Copper, cast	8.788	549.25	5.085	.317
wire drawn	8.878	543.90	5.137	.320
Gold, pure, cast	19.258	1203.60	11.145	.697
hammered	19.361	1210.10	11.204	.700
22 carats fine	17.486	1093.	10.118	.633
20 carats fine	15.709	982.	9.091	.568
Iron, cast	7.207	450.44	4.170	.260
bars	7.788	486.81	4.507	.281
Lead, cast	11.352	709.50	6.568	.410
Mercury, 32°	13.598	849,87	7.869	.492
60°	13.580	848.75	7.858	.491
Platinum, rolled	22.069	1379.31	12.771	.798
hammered	20.337	1271.1	11.769	.736
Silver, pure, cast	10.474	654,62	6.061	.379
hammered	10.511	657.0	6.082	.381
Steel, soft	7.833	489.56	4.533	.283
tempered and hardened	7.818	488.62	4.524	.283
Tin, Cornish	7.291	455.62	4.219	.263
Zinc, cast	6.861	428.81	4.970	.248
STONES AND EARTHS.				
Alabaster, white	2.730	170.62	1.580	.099
yellow	2.699	167.44	1.562	.098
Amber	1.078	67.37	.623	.039
Asbestos, starry	3.073	192.06	1.778	.111
Brick	1.900	118.75	1.099	.069
Chalk	2.784	174.	1.611	.100
Charcoal	.441	27.56	.025	.016
triturated	1.380	86.25	.798	.050
Clay	1.930	120.62	1.116	.070
common soil	1.984	124.	1.148	.071
Coal, bituminous	1.270	79.37	.735	.046
Newcastle	1.270	79.37	.735	.046
Scotch	1.300	81.25	.752	.047
Maryland	1.355	84.69	.784	.049
Anthracite	1.436	89.75	.831	.052
	1.640	102.50	.949	.059
Diamond	3,521	220.06	2.037	.127
Earth, loose	1.500	93.75	.868	.054
Emery	4.000	250.	2,314	.144
Flint, black	2,582	161.37	1.494	.094
white	2.594	162.12	1.501	.094
Granite, Scotch	2,625	164.06	1.519	.095
Susquehanna	2.704	169.	1.565	.098
Quincy	2.652	165.75	1.534	.097
Patapsco	2.640	165.	1.527	.096
Lockport	2.655	166.	1.566	.098

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*This is not correct. It should be, multiply the specific gravity by 1000 and then divide by 16. (Or first expunge the decimal point and then divide by 16.)—THE AUTHOR.

TABLE OF SPECIFIC GRAVITIES.

ivide the Specific Gravity by 16, and the quotient is the weight of a cubic foot in lbs.	Specific Gravity.	Weight of a cub. foot in	W't of a cub. in. in	W't of cub. in.
		LBS.	OZ.	LBS.
rindstone	2.143	133.93	1.240	.077
ypsum, Opaque	2.168	135.50	1.254	.077
one, white, razor	2.876	179.75	1.664	.104
imestone, green	3.180	198.75	1.840	.115
white	3.156	197.25	1.826	.114
ime, compact	2.720	170.0	1.574	.098
foliated	2.837	177.4	1.642	.102
ime, quick	.804	50.43	.465	.029
anganese	7.000	437.50	4.051	.252
arble, African	2.708	169.25	1.567	.098
Egyptian	2.668	166.75	1.544	.097
Parian	2.838	177.37	1.642	.103
common	2.686	166.75	1.554	.097
French	2.649	165.56	1.533	.096
white Italian	2.708	169.25	1.567	.098
Rutland, Vermont	2.708	169.30	1.567	.098
Castleton	2.673	167.	1.546	.097
Stockbridge	2.669	166.86	1.545	.097
ica	2.800	175.	1.620	.100
illstone	2.484	155.25	1.431	.090
orcelain, China	2.385	149.	1.322	.086
umice Stone	.915	57.18	.530	.033
aving Stone	2.416	151.	1.398	.088
orphyry, red	2.765	172.81	1.600	.099
otten Stone	1.981	123.81	1.146	.071
and	1.800	112.50	1.041	.065
hale	2.600	162.50	1.504	.096
ate	2.672	167.	1.546	.097
tone, Bristol	2.510	156.87	1.452	.091
common	2.520	157.50	1.458	.091

MELTING POINTS OF SOLIDS.

Platinum, palladium, rhodium, lime, silex, fine porcelain, can be melted in small quantities y strong lenses, or the hydro-oxygen blowpipe. * * *Plaster of Paris, common ottery,* at 150° to 180° of Wedgewood's pyrometer; say 20,000° to 24,000° Fahr. *Iron, red hot* in day light), 1207° Fahr.

		Fahr.	Wedgewood.
	*Gold	5,237°	= 30°
	*Silver	4,717°	= 28°
	*Copper	4,587°	= 27°
	Brass	3,809°	= 21°
	Flint glass	2,377°	= 10°
	Antimony	809°	
	Cast iron	2780°	
	Zinc	680°	
	Lead	612°	Experiments of committee of the Franklin Institute.
	Bismuth	506°	
	Tin	442°	
Alloys.	Lead 2, Tin 1 (common solder)	475°	
	Lead 1, Tin 1	393°	
	Lead 1, Tin 2 (soft solder)	360°	
	Lead 1, Tin 1, Bismuth 1	272°	
	Lead 2, Tin 3, Bismuth 5	212°	

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*The authorities expose absurd variations, for the high temperatures of fusion, of the ollowing metals: where gold is by some placed at 2192°, copper at 2060°, and silver at rom 1000° upwards; but it may be practically stated that gold melts at *almost white heat,* opper at *strong red,* and silver at *full red;* whilst pure wrought iron requires the strongest eat of the wind furnace.—[THE AUTHOR.

COMPARATIVE PRICES OF METALS.—One pound of indium will purchase 132,354 pounds of ron, about eight and a half of gold, 22½ of platinum, 135 of silver, 1,018 of nickel. 1,654 of ercury, 6,617 of antimony, 7,780 of tin, 10,180 of copper, 17,650 of zinc, and 24,070 of ead.—*Les Mondes.*

TABLE OF THE COHESIVE FORCE OF METALS, ETC.

Weight or Force necessary to tear asunder 1 *Square inch, in Avoirdupois Pound*

METALS.

	LBS.		LBS.
Copper	22,500	Iron, medium bar	60,0
wire	61,200	inferior bar	30,0
Gold, cast	20,450	Lead, cast	8
wire	30,888	milled	3,3
Iron, cast; grey, 2 fusion	30,680	Platinum, wire	53,0
English	52,000	Silver, cast	41,0
French	70,000	wire	38,2
French, soft	63,600	Steel, soft	120,0
German	68,300	fine	135,0
Iron, wrought	60,000	razor, tempered	150,0
Swedish	72,000	Tin, cast block	5,0
English	55,872	Zinc, cast	2,0
German	69,000	sheet	16,0
Iron, wire	85,700 113,		

Strength of Alloys when pulled in the direction of their Length.

PARTS.	PART.	LBS.	PARTS.	PART.	LBS.
Gold 5,	Copper 1	50,000	Silver 5,	Copper 1	48,00
Brass		45,000	4,	Tin 1	41, 0
Copper 10,	Tin 1	32,000	Tin 10,	Antimony 1	11,00
3,	1	36,000	10,	Zinc 1	12,9
4,	1	35,000	10,	Lead 1	6,80
Bronze (gun metal)		30,000			

WOODS.

	LBS.		LBS.
Ash, white, seasoned	14,000	Mahogany	21,800
red, seasoned	17,800	Spanish	12,000
Birch	15,000	Maple	10,500
Bay	14,500	Oak, American, white	11,500
Beech	11,000	English	10,000
Box	20,000	seasoned	13,600
Cedar	11,400	Pine, pitch	12,000
Chestnut, sweet	10,500	Norway	13,000
Cypress	6,000	Poplar	7,000
Deal, Christiana	12,400	Quince	6,000
Elm	13,400	Sycamore	13,000
Fir, strongest	12,000	Teak, Java	14,000
, American	8,800	Walnut	17,800
Lance wood	24,000	Willow	13,000
Lignum vitæ	11,800	Yew	8,000
Locust	20,500		

MISCELLANEOUS SUBSTANCES.

Brick	290	Mortar, 20 years	52
Glass plate	9,400	Slate	12,000
Hemp fibres glued together	92,000	Stone, fine grain	200
Ivory	16,000	Whalebone	7,600
Marble	9,000		

CHAPTER VIII.

ASSAYING AND REFINING OF GOLD AND SILVER.

The assaying, refining, and parting of gold and silver are the most important of all metallurgical operations; for they are not only valuable metals in themselves, but also those that are universally used as representative mediums for obtaining possession, by exchange, of everything of the slightest utility or value.

Profitable quantities of either, or both, may be so equally disseminated or scattered throughout rocks, as to lie in perfect concealment, from even the experienced observer; whilst the more ordinary explorer for fortune may, for lack of knowledge in testing and assaying, stride over and pass immense riches, in a state of most deplorable unconsciousness, to more distant regions of hopeless poverty.

Therefore, considerably more space has been devoted to these precious metal subjects than for those of the more readily known and less valuable base minerals; so as to supply, under all circumstances, some ready means, from the many given, for ascertaining both their presence and value.

1. *Of Gold and Silver, fluxed with the harmless excesses of iron, litharge, and carbonate of soda; some litharge being simultaneously reduced, by charcoal, to a suitable button of lead.*
2. *Cupellation of lead button to obtain Gold and Silver.*
3. *To calculate the ounce and coin values per ton.*
4. *New method for dispensing with calculation for dollars and ounces, and all other coin or weight values, per ton.*
5. *Preliminary roasting of suitable quantities for crucible or machine, and subsequent fusion with safe fluxes.*

6. *Separate first oxidation of the base minerals by fusion with nitre, and prompt secondary reduction by the decomposing and reducing fluxes of litharge, carbonate of soda, and charcoal.*
7. *Water analysis, and direct fusion by appropriate quantities of nitre, and other suitable fluxes.*
8. *Double smelting method. By experimental preliminary fire assay, for first lead button, so that it may be properly fluxed in the second and real assay, to obtain a button of suitable size for cupellation.*
9. *Assaying of Gold and Silver by scorification. Assaying furnace. Hints for simplifying operations during smelting, scorifying, and cupelling, by an alphabetical and numerical cabinet. Fluxing the sample, and scorification in muffle.*
10. *Assaying auriferous sulphuret and free Gold by preliminary water concentration, finished after roasting, by crucible, scorifier, machine or blow-pipe, so as to ascertain how much can be obtained by chloridation. A, B, and C.*
11. *Assaying free Gold after water concentration, by mercury, crucible, scorifier, and machine or blow-pipe, to know what can be obtained by amalgamation. A, B, and C.*
12. *Assaying free Gold in quartz, by water and ordinary tools; and then smelting into button, by machine or blow-pipe.*
13. *Gold and Silver assays with common blow-pipe. (By the elaborate methods described in books.)*
14. *Management of scales, when weighing small buttons of Gold and Silver, with modes of calculating results in hundredths and thousandths, or ounce and money values per ton.*
15. *The assaying of Silver ores by the "Wee Pet" machine.*
16. *The assaying of Gold quartz by machine, in its own independent way, after water concentration, by fluxed fusion; reading the dollars per ton, for Gold, at sight, by the same figures as those used for the self-calculation of Silver, under the last heading.*
17. *Assaying Bullion by blow-pipe and machine, for dollars per ton and thousandths fine.*
18. *Assaying of Gold sulphurets after concentration by roasting, acids, and water; by smelting the residue with machine or blow-pipe.*

19. *Assaying of Silver by roasting, acid, salt, and machine or blow-pipe.*
20. *Assaying of Silver by ammonia, acid, salt, and machine or blow-pipe, without roasting.*
21. *Humid assay of all kinds of Silver ores.*
22. *The "volumetric" assay of Silver by salt solution.*
23. *Assaying of Gold by aqua regia, etc.*
24. *Assaying of Gold by chlorine gas. A, B, and C.*
25. *Assaying of Bullion, or parting Gold from Silver and the base metals, by furnace and acid.*
26. *Extraction of Silver from a fluid alloy of Gold and Silver, by chlorine gas.*
27. *Parting of Gold and Silver, when amalgamated with mercury.*
28. *Refining of Gold and Silver from all sources.*
29. *Tables for the coin values of Gold and Silver, at all degrees of fineness.*

It requires an especial education, as well as long and varied practice, to become a thoroughly good commercial assayer; for, by fluxing improperly with the more potent chemicals, for lack of knowledge and minerals' constituents; or by excess of heat, incomplete or protracted fusion of the sample and purification of button, for want of practical ability; the greatest errors will be continually recurring: so that not only is a complete knowledge of the minerals necessary, but the exact actions that will be created by correct proportions of such fluxes as shall best decompose and oxidize or reduce to metallic states; and also the equally important knowledge as to the proper appearances of pure buttons of gold and silver.

In treating this subject, it will therefore be necessary, so as to conform to the practical requirements of the public, and to the generally expressed purport of this book, to avoid the more difficult and uncertain direct methods, where such dangerous and treacherous fluxes are required; and to favor the more exacting and available preliminary chemistry of fire for roasting such changes, that ordinary and safe fluxes shall, at high temperatures, form sufficiently fusible slags for complete reduction and collection of their conquered and more tractable constituents, int the simultaneously reduced button of lead from litharge. The are thus collected and united by the lead as alloys which als contain the precious metals; and then cupelled in the usua manner.*

ASSAY OF GOLD AND SILVER BY CRUCIBLE.

Take any sample of mineral which has been so pulverized tha not less than 3600 will pass through an area of one square inch, (60 to a lineal inch,) and mix it very intimately, by most conscientiously treating it as described in Chapter I of this Section, on the systematic preparation of the sample, both before, and after sifting; and, if any time has intervened, this should be again repeated just before weighing; so that none of the fine or heavy particles that may have settled to the bottom, shall thus cause inaccurate results. When absolutely correct assays are required, you should not forget to closely observe the upper side of the sieve, for flattened disks of gold, copper, or silver, and cakes of tough chloride or bromide of silver, which had not passed through; so that, if any are found, they can be collected, cupelled with lead, and weighed; by which their ratios to the weight of the *whole pile*, and by calculation to the *sample*, may be known. If moderate accuracy is sufficient, the sieve may be inverted and lightly struck with some hard substance, to overcome cohesion and detach the adhering particles, so that they may fall on the pile, and be then thoroughly and equally mixed therewith. To more fully accomplish this desirable result, the gauze of the sieve should also be rubbed over the exterior top with the finger, so as to release what may have been confined within the meshes.

After this pulverization and sifting, the resultant heap, by being mottled and more or less stratified, will be irregular in its quality, because the softer and more friable pieces passed through first, and these are often richer than the longer-resisting quartzose gangue. It is a complete fallacy to suppose (as many do) that the sieve is in itself an equalizer; for the very reverse is thus shown to be the case, by the variously colored stratifications on the sifted heap, and therefore it is imperatively necessary for perfect homogeneity that it should be *again mixed as before* by repeated collections to the center, and trailings by the finger of watch-spring shaped furrows, from the center outwards, before the sample is taken for the assay. (See Chapter I, Section III.)

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* The materials that are required in this Assaying and Discrimination section may be obtained, (when ordered by the names given,) from any respectable chemical firm.

1. THE MOST REFRACTORY SAMPLE OF GOLD OR SILVER MAY BE SMELTED STRAIGHT THROUGH, IN CRUCIBLE, BY ONE OPERATION; IN THE FOLLOWING MANNER:

Select a good crucible, about six inches in height, and three inches internal diameter. Weigh (with a balance that should at the worst, turn with one-tenth of a grain) 200 grains of this sample, taken from many places around and throughout the prepared heap, which dry in a porcelain basin, by placing it as a lid over a coffee-pot or kettle of boiling water, if no better means are at hand, to ascertain its loss of "water-weight," by re-weighing; when necessary to do so for the American or English markets, according to their different practices. In weighing the quantity for assay, on an unknown or common balance, it is more correct to first place the weights in the same pan as the ore is to be weighed, and after balancing the beam with some convenient material, to then remove them and substitute ore until the lever with its pans are again brought to correct balance. This method will give exact results, even if the sides of the beam are of greatly unequal lengths.

Place this weighed sample of 200 grains in a clean, dry saucer, and add thereto 4000 grains of litharge, 400 grains of carbonate of soda, and about 20 grains of finely pulverized charcoal. Mix most intimately in the manner described; transfer it to the crucible, and vertically insert therein a four-inch iron nail, which will aid in the riddance of the sulphur by forming a sulphide of iron slag. Next loosely cover it with 50 grains of borax *glass;* and, lastly, by an equal layer of common salt.

Borax glass is produced by being previously fused at a red heat in a crucible, and poured into a frying-pan or mould, which reduces it to a compact glass, by expelling the water of crystallization.

Place this crucible in a moderately strong fire; surround and support it securely by charcoal or coke (the latter makes the better and more enduring fire), then cover it with a large piece, and increase the heat of the fire as rapidly as possible; notice when the crucible becomes bright red and its contents are in fusion, and allow fifteen minutes more to pass away beyond that time; then stir the contents with a quarter-inch iron wire, previously made white-hot in the fire, for about five minutes; and after closing the furnace for another fifteen minutes, so as to produce the greatest possible fluidity, carefully withdraw the crucible from the fire, tap it gently on a flat, hard surface of iron, brick or fire-rock, to precipitate from the slag any floating globules of lead, for union with the larger button of general alloy at the bottom, and allow the crucible to rest in a vertical position thereon until quite cold. As this method yields a large button of lead, it had better be cupelled in the scorifier full of bone ash, as will be described under the next heading of "Cupellation of Button."

The unusually refractory sample of this example was intentionally selected because of its being almost entirely composed of sulphurets; but it will generally be advisable to concentrate by water, and to dry and weigh as described, to ascertain the quantity of sulphurets, and treat accordingly, so as to economize fluxes. The minimum weight of these will, however, be, for even ores that contain no sulphurets, as follows:

For 200 grains of ore,
200 grains of litharge,
100 grains of carbonate of soda,
6 grains of powdered charcoal.

Cover by 50 grains of borax glass, and this by a table-spoonful of salt; the litharge, carbonate of soda and charcoal, being the variable quantities over these amounts, according to the quantity of sulphurets present.

If you have many assays of this class to pass through, you may make a self-calculating scale, like that illustrated by Figure 26, under the heading of "Water Examination and Direct Fusion with Nitre," so as to economize fluxes.

2. CUPELLATION OF BUTTON.

One of the suitably porous materials must now be selected, and cupels made therefrom in the ordinary moulds, so as to cupel the button thus obtained from smelting: these may either be bought ready for use, or made in the following manner:

Take some bones, either beef or mutton—the last are better—which burn in a moderately hot fire for a few hours, until they become quite white. Pulverize in a mortar, and, after sifting the whole through a fine sieve, next rid it of its soluble lime by water-washing, *without rubbing*, (which will, by smoothing its angularity, lessen its cohesive strength,) then pour the water into another vessel, so as to settle the impalpable and insoluble powder, when the water may be finally poured off, and the contents of both vessels slowly dried and separately bottled.

Cupels may be made in two ways, for present use, or as reserved stock. The first I have made by ramming moderately moistened bone ash from the first and largest bottle into an old, previously used scorifier, and then shaping a concavity for the button with some suitably formed tool, that happened to be around. These, thus easily made, are very suitable and safe, where large buttons of rich metal have to be refined by cupellation; as the enclosing scorifier not only thus readily forms and retains a *large quantity* of ash, but *collaterally secures* its contents. A percussion-cap box may be used in the same manner, if the ash is *slowly dried*, as it serves for a mould, and, before the solder gives way, the cupel will become sufficiently secure.

You should avoid the use of a silver spoon for smoothing the rough bone-ash for cupel, as the silver would be likely to rub off and falsify the result.

Those who are comfortably fixed, had better buy the more fragile naked cupels, or make them by especial "cupel moulds," as sold for the purpose. The ash, in this case, is made just barely wet enough to hold together, and rammed into the mould with a suitable pestle, by a wooden mallet, when the thus formed cupel is forced out, *during the twisting of the pestle*, slowly dried, and stored for use when required.

In both these modes of manipulation, the cupels will be greatly improved in quality, when the slightly moistened pestle, after being dipped into the finer ash from the second bottle, is replaced into the mould, so that the surface of the cupel may be smoothed by suitable pressure and twist. By thus forming a compact surface filter for the base oxides to pass into the more porous interior, the loss of gold and silver is not only lessened, but a better bed for minute buttons is also provided. Cupellation is thus performed because gold and silver, by oxidizing very slowly, keep a substantial globe on the surface, for a very long time after all the base metals have oxidized by dry sublimation in air, and liquid or fluid infiltration into the porous support.

The cupel, or cupels, should have been dried and placed in the hot muffle during the smelting operation, so as to be in the proper condition, at *high red heat*, for the reception and speedy liquefaction of the button for refinement.

The perfectly cold crucible may now be carefully broken, and its contents of slag and metal enclosed in a strong rag or several folds of paper, and smashed with a small hammer and anvil, or between two hard stones, into numerous small fragments, so that the metal may be extracted from the scattering debris, in one or more buttons of the alloy.

This method for separating the slag and retaining the button is only intended for those who may be deficient of more regular assaying tools.

These buttons must now be thoroughly cleaned, by hammering or pliering into solid forms; and thus further ridding them from the adhering flux and slag, by crippling the surface and compaction of the metal, they are more easily cleaned with a brush; their specific gravity being also increased by this compression, they are then more readily fused to lively and bright molten metal upon the hot bone ash in muffle, for an effectual start forward in refinement to gold and silver.

The button being placed on this bone ash scorifier or cupel, in the muffle, it must be watched for a minute or two, to see that it becomes fluid to molten brightness, and that it does not run over the margin. After this, a medium or high red heat is all that is required, just between the *freezing* on the bone ash of the oxide of lead thus formed, and *excess* of white heat: if the bone ash is sufficiently hot to absorb the oxide in liquid condition without leaving a surface incrustation, and the metal is molten and transfers colored spots of oxide from the center to the circumference of the button, and the fumes are reddish brown, arising lazily to mid-height of the muffle, it is at a proper degree: but if the cupel and button and the volatile oxide are quite white, and the fumes arise from the button to the very top of the muffle, it is too hot, and consequently wasteful.

At the end of this process, the heat should, however, be increased, by moving a little inward, as gold and silver melt at a much higher temperature, and their concentrated alloys at a corresponding degree; so that a superior heat is absolutely necessary to continue complete fluidity, for passing off its more stubborn, last-remaining base metal associates.

Towards the end of the refinement, a rapid circular motion, or spinning of the last oxides, may be observed, which is also accompanied by a flashing play of rainbow colors immediately preceding what has been called the "brightening" of the silver and gold; which is also the signal of completion, and for removal from the muffle. This so-called brightening is not well expressed, for it is really a darkening from the rainbow play of colors to that of a mirror in a shadowed position, or a water-like appearance, that the globule sometimes for a few seconds approaches more to being altogether invisible than brightly so.

On removing the cupel with a pure silver button from the muffle, it exhibits during cooling, first a flash of light of the whole exact size and shape of the sphere, and then after a few more seconds, small warty protuberances begin to burst out as if from miniature volcanoes, this has been supposed to be occasioned by the escape of oxygen, which, having lost its affinity for silver from reduction of temperature, escapes thus suddenly through the solid crust in this manner; sometimes one may appear, and at others several, the latter giving a peculiarly rough frosted appearance to the whole surface. These are faithful records that the button is free from base metals, and chiefly if not entirely composed of pure silver. Silver is the whitest metal, and flattens like lead to a thin disk without fracturing the edges. Gold is the only yellow metal; the yellow alloys called brass should have passed away with the litharge into the bone-ash. (See foot notes at pages 227 and 250.)

Large buttons must be cooled more slowly, or a considerable loss may be occasioned by this peculiar spurting.

When a very large quantity of nickel, copper, or iron, is present, it will be sometimes observed that the button lacks fluidity, and cannot be oxidized to less than a certain size, where it solidifies or forms an incrustation of oxide from the refractory metal; in such cases more lead must be added, so that by forming more oxide or litharge, it may be liquefied and passed into the ash, until it is completely ridded from the incumbrance.*

3. TO CALCULATE THE VALUE OF A THUS OBTAINED BUTTON, IN TROY OUNCES, OR DOLLARS PER TON, YOU MAY REASON AND PROCEED AS FOLLOWS:

The 200 grains have been here selected as a suitable quantity, that also conforms to the American ton, for estimating gold and silver, both as regards the number of units, for more plainly explaining the basis for calculation, and to be sufficient for most gold rock, as well as for affording a large average on the silver ores. Any quantity taken for the assay has been conventionally denominated the "assay pound" by authors, for no apparently good reason; so that we will multiply this 200 by 10, and call it the assay ton (of 2000 pounds), and the weight that equals one-tenth of a grain shall be denominated the 'assay pound,' or one-two-thousandth, both being avoirdupois. This pound being always thus regarded as the unit for calculation by the decimal system, the point standing at its right, thus—1.

Now, as the 200 grains contain 2000 tenths of one grain, this one-tenth being unity, it stands in similar ratio as one pound does to the ton of 2000 pounds; so that, if the sample just assayed yielded a pure button of gold or silver of this exact weight of one-tenth grain (the space in the box for this unit should be marked), it would stand as unity, with the decimal point on its right, and would also mean that 2000 pounds, or the ton, had yielded one pound of gold or silver, and that as *ounces* or *dollars* must be certificated, all that remains to be done is to multiply it by the number of ounces troy, or dollars that are contained in this avoirdupois pound: thus, for ounces of gold or silver; 1.x14.58=14.58 oz. per ton; and 1.x18.85=18.85 $ silver per ton; and 1.x 301.367=301.367 $ of gold per ton; which is continually varied as the results; thus, a sponge of gold from an alloy of the above weight may weigh, after it is parted from silver by acid, .01 of a grain's tenth, which, being multiplied by 301.367, will equal 3.01367, or 3 $ .01 cent gold; and, if this weight be deducted from the original button that weighed 1. it will give the correct weight of silver; or the remainder of .99 thus obtained, multiplied by 18.85, will equal 18 $ .66 cents per ton for silver. When accuracy is imperatively necessary, certain additions and reductions are sometimes made to the weight of the button thus obtained, previous to its being certificated for commercial purposes. The first has been alluded to when disks of metal, etc., are found in the sieve, which may be thus calculated. If the weight of the pulverized pile, including the disks, is 1122 grains, and the disks .09 (or nine-hundredths of a grain), first, for a better explanation, multiply each by 10, so as to get them into corresponding units, (or assay pounds), with the sample, and they would stand thus: 11220 tenths of a grain, and .9 (nine-tenths of one grain). Now, if 11220 tenths give .9, what should be the allowance for the assay ton of (200x10) 2000 tenths? 2000 multiplied by .9=1800.0, which, divided by 11220, will give .16 to be added to the assay button obtained from a similar amount of ore that did pass through the sieve; so that, if this assayed 1. as before, the .16 being added, it will then be 1.16 for calculation.

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* It must not be understood that these exudations are certain evidences that the *whole* button is *pure silver*, for although *base* metals are *absent*, *gold* may be *present*; as it requires a considerable *value* in gold to completely prevent their formation.

The next allowance is for the silver in the litharge, or lead, which often contains more than should pass unchecked. One means for ascertaining this is, after thoroughly mixing your newly received litharge, to take exactly as much as you did of the ore for test assay, and to flux and fuse in precisely the same manner as before, to then cupel the button, and deduct the weight of silver obtained, which may be supposed to have been .01 of the unit of one-tenth grain; the former figures will have to be corrected from 1. to .99, which being multiplied by 14.58, or by 18.85, will respectively give the correct value in ounces, or dollars of silver per ton; the weight and value of the residue of gold being precisely the same as before. This explains the principle, but in practice it will be better to take tests of silver in litharge and lead, for all the quantities used in crucible and scorifier assays, to calculate the *dollars and cents* instead of *weight reductions* for each, and book them for reference as required for subtraction, from the full weight *false* value.

It will be well to dissolve this button from test lead in nitric acid, so as to be certain that the lead contained no gold, as it almost invariably contains silver, and sometimes a little gold.

If the large English ton of 2240 pounds is required, by taking a corresponding assay ton of 2240 grain tenths, the same multipliers may be retained. Suitable multipliers may be also directly used for any other quantities that are taken for the assay, from "rule of proportion," or proper multiplication and division; in this matter, divisible numbers of 2000 and 2240 had better be taken as 1000 or 1120 for half tons; 500 or 560, quarter tons, &c. (the latter being suitable for scorification); and either multiply the weight of the button by 2 or 4, &c., and then proceed to calculate as before, for a full assay ton; or multiply the aforesaid multiplying numbers by 2 or 4, &c., for *directly constant multipliers* for buttons obtained from these respective quantities. See tabular multipliers under heading 14, for weighing and calculating values of small buttons.

4. CALCULATION MAY BE ENTIRELY DISPENSED WITH, BOTH FOR OUNCES AND DOLLARS PER TON:

By taking a similar nominal weight or quantity equal to the number of ounces (29160) and dollars (37710) contained in a ton, instead of the "assay ton" just explained; you may have the result represented in ounces or dollars, for different tons by the weights themselves, as they lie in the pan, by decimating two right-hand figures thus: 291.60 grains or 377.10 grains for the self-calculating "assay tons."

If you wish to use this method, it will be better to make especial weights for the assay ton, the first marked ounces per ton, the second dollars per ton, &c., so as to save any further recurring attention.

To have the result in ounces, take the weight marked ounces per ton, for your sample; weigh, flux in proper ratio, smelt by crucible, cupel, and weigh the resulting button; the smallest aluminum weight of the Oertling's set of weights, or the one-hundredth of 1 grain, will then be your unit, and when the weights are placed on paper, they will record at sight the number of *ounces* of silver or gold in a ton of say 2000 pounds, or of 29160 ounces. By dividing the beam into tenths and hundredths, the hundredths of an ounce will be read by having a *white silk or thread* rider made equal to one-hundredth of one grain, which is the representative weight of one ounce. The pennyweights and grains may be read with equal facility by dividing the lever, at the *other end*, into twenty parts for pennyweights, and these again into twenty-four smaller parts for grains, by using the same thread rider. The *dollars and cents* of silver may be ascertained with even greater facility when the appropriately marked assay ton weight of 377.1 grains is used for tonnage and the same unit or dollar weight as a rider, the cents being then immediately read on the side of the lever marked into one-hundredths.

The box that contains the weights may be marked units, tens, hundreds, thousands, just opposite where they lie in their recesses; so that, by taking and *first calling* the largest weight or weights from the pan, it will sound exactly as it is; thus, 162.36 grains, after casting the decimal point away, would be sixteen thousand two hundred and thirty-six dollars per ton; and then again, by supposing the weight .0124 grain, when the rider is also used, it would sound one dollar and twenty-four cents, (or one ounce and twenty-four hundredths by its assay ton), which, being read at the other end of the lever, would be one ounce, four pennyweights, and nineteen grains. The ounce result is of course common to both silver and gold.

If gold is required in dollars, either use 15.9873 times (16 times is very near) as much for the *assay ton* as this for silver dollar weight and value, or multiply the weight obtained by the silver ton by 16, for its value in dollars of gold per ton. This self-calculating "assay ton" for gold will be 6032. grains, and then the *same weights* will represent exactly the *same gold value* as that just described for silver, because the quantities taken for samples are intentionally arranged for the purpose.

This is of course founded on the nominal value of each metal, but should real values change, the discount must be entertained and allowed for.

Should ounces be required instead of dollars, from this last *gold sample*, divide by 16 (or the closer decimal numbers).[*]

These quantities of 291.6 and 377.1 grs. of ore, though suitable for crucible, cannot be passed through the scorifier, and when intended for silver assays, they must not be concentrated by water, as it would cause great loss of rich fine powder, and obtain far too little value; but it fortunately happens that a tenth of this *assay ton* quantity is just within its power, said to be 50 grains; but which, being governed by the natures of the ores, varies very much, and therefore 37.71 grains will be the safer quantity.

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[*] This appears a large quantity, and so much the better, for it will give a larger and safer average, and after the water concentration described and recommended in preceding chapters, the much lessened heavy residue can always be very easily treated by scorifier or crucible, and sometimes by blow-pipe.

To render this practical with the balance, the tenth of the former unit must be taken as unity, by using this same unit as a rider upon the beam, so that when this rider is moved to balance at the first mark, at one-tenth from the fulcrum, it will represent one ounce, or one dollar (instead of the one-tenth as before stated), and so on from 1, 2, 3, 4, 5, 6, 7, 8, 9, until it reaches the tenth mark, which is immediately over the scale pan, and of course is 10 ounces or dollars (and the same as when placed in the pan itself), the cents, or dwts. and grs. being now read between these marks of tenths upon the beam.

5. ANOTHER SAFE AND EASY METHOD IS FIRST TO DECOMPOSE AND OXIDIZE THE BASE MINERALS BY THOROUGH ROASTING, AND THEN TO FINISH BY USING ORDINARY QUANTITIES OF THE FLUXES WHICH FORM FUSIBLE SLAGS, AND FLUID ALLOYS.

Weigh 200 grains of the ore that contains refractory sulphurets, arseniurets, etc., which mix intimately with 50 grains of pulverized charcoal, common black lead, or graphite, and roast within a sufficiently large crucible for at least a half-hour, at red heat, during almost continual stirring. Remove it from the fire, and, if no fumes arise, this process may be considered to have been well performed; but if, however, they can still be detected, even by odor, the sample must be pulverized in the same vessel by grinding, then remixed with a similar quantity of charcoal, and be again roasted, until no more fumes are volatilized.

To this roasted ore (which weighed 200 grains before roasting), add 400 grains of litharge, 100 grains of carbonate of soda, and exactly 6 grains of charcoal (so as to reduce from the litharge by this amount of charcoal, the proper weight of lead for cupellation). Mix intimately, cover with 50 grains of borax glass, this again by a tablespoonful of common salt, and then smelt, cupel, and calculate as before.

6. IT MAY BE PERFORMED BY SMELTING, DIVIDED INTO TWO OPERATIONS, AS FOLLOWS:

The first being the oxidation of the base metals by nitre, the second, by charging thereon, (after the strength of the nitre has been neutralized and volatilized,) a mixture of litharge, charcoal powder, and carbonate of soda, to more promptly collect the gold and silver by the shower of molten lead thus reduced and precipitated, to a suitably sized button, for cupellation.

The advantages of this method are:

1. That it extracts, without roasting, as much of the precious metals as any other crucible mode.

2. That it may be performed with much less knowledge of the chemistry of fire and fluxes, without risk of insufficiently correct results.

3. The nitre being first and *separately* used, in sufficient quantity for the worst ores, thoroughly oxidizes the base minerals without interfering with the proper size of the subsequent lead button which by the *ordinary* method has to be simultaneously produced (after the test assay) by proper fluxes.

4. It does not oxidize the precious metals.

5. The button of lead for cupellation may be thus promptly and correctly reduced from the oxidized mass by *subsequent* addition of litharge, carbonate of soda, and charcoal, to the desired size for obtaining the greatest amounts of gold and silver by cupellation.

6. It requires neither separate crucibles, nor *doubly fluxed and smelted "preliminary" tests* and *real* assays, but may be performed by the same fusion, in the following manner:

Take (the worst of all examples) a sample of finely pulverized, very closely concentrated, *unroasted* sulphuret of iron, that contains but little gold, and weigh out 200 grains, in the careful manner described for previous assays. Now, to completely oxidize the sulphuret of iron by fusion with nitre, it will require about 2½ parts of the latter to 1 part of the former; so that we must now add 500 grains of nitre, and thoroughly mix in a crucible with the 200 grains of ore, which should occupy about one-half the capacity of the crucible, as this flux, being somewhat violent in action, would otherwise, more particularly when charcoal happens to be also present, discharge some of the contents, and cause considerable loss. Place the crucible into a moderately hot fire, and after the sample is smelted into a state of complete fusion, which will occupy about fifteen minutes, stir it with a hot iron wire for about five minutes; then add quickly, with a long-handled scoop, an *intimate mixture* of 200 grains of litharge, 200 grains of carbonate of soda, and 6 grains of finely pulverized charcoal, previously prepared and scooped for more immediate charging. Smelt at full heat for ten minutes, and if then quite fluid, withdraw it from the fire, tap the crucible upon the hearth to settle the lead, and, after it is quite cold, break it and extract the button, when after it is cleaned and properly solidified, you may cupel to a pure globule, and calculate for value as previously directed. If the operation has been well performed, this button from the crucible should weigh from 150 to 180 grains.

7. WATER EXAMINATION, AND DIRECT FUSION WITH NITRE, ETC.

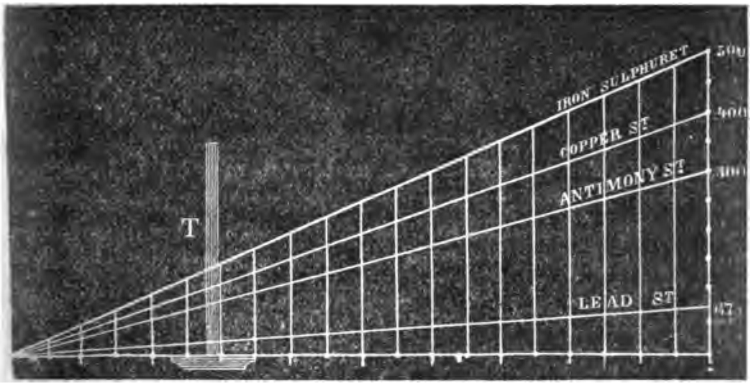
Concentrate 200 grains by water, dry the heavy residue in a basin or plate, over a suitable pot of boiling water, and carefully examine for the different sulphuret minerals, which separate into heaps, and weigh for more accurate and economical fluxing by nitre, litharge, carbonate of soda, charcoal, borax, and salt, assisted by the following table and geometrical device:

To oxidize 200 grains of sulphuret of iron, it requires about 500 grains of nitre.
To oxidize 200 grains of sulphuret of copper, it requires about 400 grains of nitre.
To oxidize 200 grains of sulphuret of antimony, it requires 300 grains of nitre.
To oxidize 200 grains of sulphuret of lead, it requires 67 grains of nitre.

Now, having ascertained by water concentration how much of either of these sulphurets are contained in your sample of 200 grains, you can weigh another sample of 200 grains, and add thereto the exact amount of nitre required, which may be ascertained in the following manner: If say 20 grains of the sulphuret of iron were obtained, it would require but just one-tenth as much nitre as it did when the whole 200 grains of sulphurets were present. Or, by proportion, if 200 grains of sulphuret of iron required 500 grains of nitre for its complete oxidation, how much nitre would 20 grains of sulphuret of iron require; or $\frac{500 \times 20}{200} = 50$ grains of nitre.

When many assays are required, much time may be readily saved by using the device of Figure 26, either for these or any other ratios, as follows:

Figure 26.



Lay out a straight base line upon a suitable board or table, which divide, from left to right, into 200 equal parts, (to represent the grains of the assay); erect (by a square) at the extreme right, on the two-hundredth mark, a perpendicular line, which also mark off, by commencing at the bottom, equal units, until the maximum number and height of 500 are obtained (the greatest quantity of nitre required), and mark every tenth division of the base and perpendicular lines with their proper figures. Next draw *four* diagonal lines from left to right, the *first* commencing at the zero of base (or left end of the 200 line), and ending at the 500, or top of perpendicular; the *second*, from this zero to the 400 of perpendicular; the *third*, from zero to 300; and the *fourth*, from zero to the 67 grains of nitre required for oxidation of 200 grains of sulphuret of lead, and it is complete for immediate reference, for ascertaining how much nitre is required for the oxidation of any fractional number below 200 grains of either of these sulphurets. Any number of other diagonal lines may be also drawn on the same board or paper, and suitably marked for the particular sulphuret or purpose, for which the *ratio* of this or any other flux is required. The base line may be also divided into hundredths when preferable; or into *both at the same time*, by *darkening* the *alternate* marks, and figuring both *over* and *under* the line; the first showing one-hundredths, and the second two-hundredths.

All that is necessary to be done for using the instrument is to apply a square to the board, so that its perpendicular edge shall stand over the figure on the base line, that represents the weight of the concentrated sulphurets, say about 60 grains; then, with an open compass to gauge the perpendicular distance from the base line to where the square's edge crosses the diagonal line that is marked for the particular sulphuret required; next transfer the compass to the graduated vertical line; the one point being placed at the angle of intersection of base and perpendicular, the other will point to the exact quantity of nitre upon the vertical scale, that will be required to oxidize that particular metallic sulphuret. To render the compass unnecessary, the right-hand side of the blade of the square may be graduated so as to serve for measurement.

If two sulphurets are present, they must be separately reduced, by the proper quantity of the particular flux required for each metal.

The base line may also be divided into 50 equal parts, for the number of grains used in scorification, and the perpendicular into suitable unequal parts, commencing from 6 parts of lead at the base, (the least quantity of lead taken for the 50 grain assay), when iron, copper, or nickel, are absent, and so graduated that the correct number of necessary additional parts of lead may be measured by the compass, when transferred from the perpendicular height over the fractional concentrated quantity to the end scale, for the most economical proper fusion of such refractory minerals when they are present.

These calculations may be *indefinitely modified* by using different vertical and horizontal scales; and may be performed by a single angle of diverging lines, if separate scales, of the extreme vertical length, be individually divided to the number of parts required to oxidize the 200 or 100 grains of sulphurets. Thus, if the first vertical, smallest angle of measurement of the 67 were divided into 500, it would serve also for the fractional ratios of that number, when measured by its parallel and vertical line from the base, as is now done by the largest angle, when the reduced distance of the compass points are placed thereon, to ascertain the number of grains required, as denoted on its scale, under the upper point. An ordinary oblong table may be used for this purpose, by simply laying out the base line of 50 inches in length, divided into 200 quarter-inch parts; and erecting the perpendicular 31¼ inches high, of 500 sixteenths of an inch long. Or a piece of plank may be used, of half this width, divided into 500 thirty-second-inch parts. Also a common school-slate.

This exact quantity of nitre being ascertained, must now be added to the 200 grain assay, with about 400 grains of litharge, 200 grains of carbonate of soda, and, if *no lead is present*, exactly 6 grains of pulverized charcoal; but, if any lead ore is found, every 40 grains of ore should exclude about 1 grain of charcoal. Mix very intimately, and transfer it to a crucible that would hold at least thrice this quantity; and, after first covering it with about 50 grains of borax glass, and lastly, with a tablespoonful of salt, it may be smelted, cupelled, and calculated in the manner described under Nos. 1 and 2.

In addition to this mode of fluxing, it will be convenient to remember this general fact in the chemistry of fire, that the base mineral which contains the gold and silver must be either *oxidized or reduced* before all the precious metals can be collected, and it may sometimes be advantageous to add a little of each in this last stage for more complete reduction.

For example, if the rich and very stubborn *antimonial* sulphuret of silver should be present, (a no uncommon thing in this country,) cyanide of potassium would be its most effective reducing agent.

8. DOUBLE SMELTING METHOD BY PRELIMINARY FIRE ASSAY, FOR FIRST LEAD BUTTON; SO THAT IT MAY BE PROPERLY FLUXED IN THE SECOND AND REAL ASSAY, TO OBTAIN A BUTTON OF SUITABLE SIZE FOR CUPELLATION.

This mode of assay has been recommended and fully described by John Mitchell, in his large Manual on Practical Assaying; and as he has, in these paragraphs, fully exposed the dangerously doubtful actions of fluxes, and also given the means used for testing the reducing and oxidizing powers of argol and nitrate of potash, and for the assaying litharge for silver—all of which, as well as the test lead (which is known by cupellation) must be invariably examined and allowed for by you, if accuracy is required—I have quoted his instructions as follows:

"SPECIAL DIRECTIONS FOR THE CRUCIBLE ASSAY OF ORES AND SUBSTANCES OF THE FIRST CLAS.

"The ores and substances belonging to this class may, for the convenience of assay, be further subdivided on the following principle. It has already been seen that sulphur, and other substances having a great affinity for oxygen, reduce metallic lead from litharge in proportion to the amount of reducing matter present; and, as it is necessary in this kind of assay that no more than a certain quantity of lead alloy should be submitted for cupellation, some kind of control must be exercised by the assayer, to keep the quantity of lead reduced in due and proper bounds. This is readily accomplished by what the author calls a 'preliminary assay,' by which all ores and substances of this class are divided into three sections: Firstly, ores which, on fusion with excess of litharge, give no metallic lead, or less than their own weight; secondly, those which give their own weight, or nearly their own weight, of metallic lead; thirdly, those which give more than their own weight of metallic lead. The preliminary or classification assay is thus conducted.

"Carefully mix 20 grains of the finely pulverized ore (all silver ores must be passed through a sieve with 80 meshes to the linear inch) with 500 grains of litharge; place the mixture in a crucible which it only half fills; set the crucible, after carefully warming, in a perfectly bright fire, and get up the heat as rapidly as possible, so as to finish the operation in a short time, to prevent the action of the reducing gases of the furnace on the oxide of lead, because, if a great length of time were taken in the operation, a portion of the lead reduced might be traceable to the furnace gases, and the result of the experiment vitiated. After the contents of the crucible are fully fused, and the surface perfectly smooth, the crucible may be removed and allowed to cool, and, when cold, broken. One of three circumstances may now present itself to the assayer: Firstly, no lead, or less than 20 grains, have been reduced; secondly, 20 or nearly 20 grains, more or less, may be reduced; and, thirdly, more than 20 grains may have been reduced.

"Now, as it has been already stated, 200 grains of lead alloy is a suitable amount to cupel; and, as 200 grains is the best quantity of ore to submit to assay, it will be evident that ores and substances of the second section, or those bodies which give their own weight, or nearly their own weight, of lead alloy, simply require fusion with a suitable quantity of litharge and an appropriate flux. Ores of the first section require the addition of a reducing agent, in quantity equivalent to the standard amount of lead alloy (200 grains); and ores of the third section require an equivalent quantity of an oxidizing agent, or an amount of some body which will oxidize the lead in excess of 200 grains of alloy.

"The reducing agent employed is argol; the oxidizing agent, nitrate of potash. It is necessary, before commencing an assay of a silver ore, to determine how much lead a given weight of the argol the assayer has in use will reduce, as also how much lead a given weight of nitrate of potash will oxidize. These assays are thus made:

"ASSAY OF REDUCING POWER OF ARGOL.—Carefully mix 20 grains of the argol to be tested with 500 grains of litharge and 200 grains of carbonate of soda; place the mixture in a suitable crucible, and cover with 200 grains of common salt. (It is best to mix two such quantities, and take the mean of the results.) Fuse with the precautions pointed out in assay of substances of the first class, containing lead. Weigh the resulting buttons, and take a note of the mean weight, which will represent the amount of lead reducible by 20 grains of argol.

"ASSAY OF OXIDIZING POWER OF NITRATE OF POTASH.—Mix 20 grains of finely powdered nitrate of potash, 50 grains of argol, 500 grains of litharge, and 200 grains of carbonate of soda; cover with 200 grains of common salt, and fuse as above. Weigh the resulting button. Now calculate the amount of lead which should have been reduced by 50 grains of argol, and the difference between that and the amount of lead reduced in this experiment will represent the amount of lead oxidized by 20 grains of nitrate of potash. 30 to 32 grains of ordinary red argol reduce 200 grains of lead; and 28 grains of pure nitrate of potash oxidise about 100 grains of lead. The assayer must, however, adopt the numbers found by himself by experiment, as some samples of argol and nitre are more or less impure. He must also examine every fresh supply of litharge for the amount of silver it contains, in the following manner:

"ASSAY OF LITHARGE FOR SILVER.—Mix 1000 grains of litharge with 30 grains (or any other quantity that may be, by experiment, found requisite) of argol, 200 grains of carbonate of soda, and cover with salt, as already directed. Fuse the mixture in a suitable crucible; allow it to cool; break and cupel the button obtained, as hereafter to be described: take a note of the amount of silver obtained; and, as 1000 grains of litharge is the standard quantity for silver assay, the amount of silver, indicated as above, is to be deducted from the amount of silver obtained in the assay of any silver ore, until that quantity of litharge is consumed.

"ASSAY OF ORES OF THE FIRST SECTION.—Make a preliminary assay, as already described. Suppose 10 grains of lead result; then, as 20 have furnished 10 grains, so 200 grains of ore would furnish 100 grains of lead, or 100 grains less than the quantity best adapted for cupellation; so that, referring to the assay of argol, and finding that from 30 to 32 grains reduce 200 grains of lead, then it is clear that the reducing power of from 15 to 16 grains of argol, in addition to the reducing power of 200 grains of ore, is necessary to furnish 200 grains of lead alloy. In this case, the ingredients required in the actual assay, or 'assay proper,' would stand thus: 200 grains of ore, 200 grains of carbonate of soda, 1000 grains of litharge, 15 to 16 grains of argol. These materials are to be thoroughly well mixed, placed in a crucible which they about half fill, and covered first with 200 grains of common salt, and then 200 grains of borax, and submitted to the fire with the usual precautions; when the flux flows smoothly, the assay is complete; it may be removed and allowed to cool, the crucible broken, and the button obtained must be hammered into a cubical form, and should approximate 200 grains, either more or less within 10 grains. Two crucibles must always be prepared. It will also be here convenient to mention that the argol and nitrate of potash are the only substances whose quantities vary in the assay of silver ores, the amount of these variations being determined by the preliminary or classification assay.

"ASSAY OF ORES OF THE SECOND SECTION.—If the preliminary assay of the sample submitted to assay furnish from 18 to 22 grains of lead, then the assay proper may be thus made: 200 grains of the ore, 200 grains of carbonate of soda, 1000 grains of litharge; well mixed, and covered with salt and borax, as above. Fuse with due care, and reserve buttons of lead for cupellation.

"ASSAY OF ORES OF THE THIRD SECTION.—If the sample on the preliminary assay furnished 40 grains of lead, then the 200 grains employed in assay proper would give 400 grains, or 200 grains of lead in excess; refer now to note-book for quantity of lead oxidized by nitre; suppose the nitre pure as just stated, 23 grains will oxidize 100; therefore, 46 grains are equivalent to 200, and the assay proper will stand thus: 200 grains of the ore, 200 grains of carbonate of soda, 1000 grains of litharge, 46 grains of nitrate of potash. The nitrate of potash to be weighed first, finely pulverized, and then well mixed with the remaining substances, and covered with salt and borax. The crucible in this assay must be larger than in the two preceding cases; the mixture should not more than one-third fill it, as there is a considerable action set up between the oxygen of the nitre, and the sulphur or arsenic, or any other substance that may be the reducing agent in the ore; for, in fact, the nitre does not directly oxidise the lead, which sulphur, etc,, might have reduced, but oxidizes its equivalent quantity of sulphur, or whatever other reducing substance there may be in the ore, so as only to leave a sufficient amount to reduce 100 grains of lead, in lieu of the 400 as indicated by preliminary assay, or when the reducing power of the ore was allowed to come into full play. The buttons obtained in this case are also to be reserved for cupellation."—JOHN MITCHELL.

9. ASSAYING OF GOLD AND SILVER BY SCORIFICATION.

This, the cheapest and easiest, cleanest and quickest, safest, best and most scientific method for assaying gold and silver, is performed by simple means with *shallow dishes* called scorifiers, *within a hot muffle* and *surrounded* by fire, instead of being *fuse* with more studied and less certain fluxes, by *crucible*, *within th fire itself*.

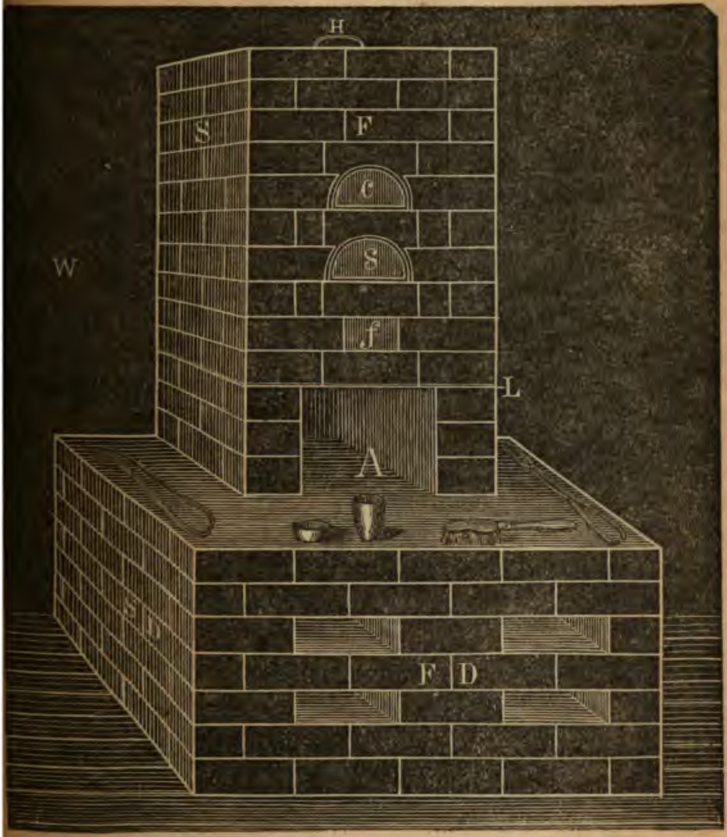
It will not be out of place just now, to give an illustration of an assaying furnace, and the most convenient, economical and suitable dimensions of its exterior shape and interior capacity, as required for the miner. I submit the following for such a purpose, which can be made either of unbaked or baked bricks; as charcoal or coke is used, although it will be better to have it lined with "fire brick."

The furnace may be built in the complete form shown, with its back abutting in an air-tight manner against the distant wall (W), whilst its thick foundation rests upon the floor.

First build the bottom dead work, marked F D (front dead work), and S D (side dead work), 4½ bricks wide in front and 3½ bricks at the side (38 inches by 34 inches), and run this work some 7 bricks or 20 inches high; thus forming a base for furnace, recesses for tools, and a convenient table for resting hot crucibles, scorifiers, cupels, tongs, etc., as well as being of suitable height for pouring ingots or buttons, and for safe bottom of ash-pit, even in a wooden-floored office. Next commence to build the bottom of the ash-pit upon this dead work, by laying 2½ bricks wide against the wall, and 2 bricks to the front of furnace; that is, about 20½ inches wide by 16½ inches, somewhat in the shape of a letter **[** with its back to the wall; this and the limbs are each 4 inches wide; next run this same shape 3 bricks high, for the ash-pit and draught-hole, and place your fire-bars and grating thereon at the dead level from L.

If you are likely to require the use of furnace every day, the bars had better be put in loosely upon transverse iron sleepers, which should be built in front and back, at the height of letter L, so that the fire-bars may be withdrawn at the termination of each day's work. Next lay on, with as little lime as possible, one row of bricks, or 4 inches wide all around (at the back, the sides, and the front), and then again another row of bricks all around, except at the opening marked F, which is intended to feed as required to regulate the heat of muffles, and which may be stopped by a brick when not being fed. Next bridge this opening by hoop-iron or bars of half-inch thick flat iron, cover-g 4 inches wide, for the full breadth of front, and sufficiently ng to turn down a half-inch at each end, to brace the furnace gether, or if you have no iron, another row of bricks, as drawn. ow lay on, exactly over opening F, the first (*scorifying*) muffle,

Figure 27.



S, so that, by resting a little higher on the *back wall* end, the drainage and discharge from within of any accidentally spilt lead (or other metal), will prevent its eating through the muffle. Just opposite the back end of both muffles, about one-inch holes should be forced through the wall of the house to the chimney, to afford direct communication and draught from the muffles, to insure more speedy oxidation of the minerals and metals. Lay another course of bricks around the furnace, and build clo up to the sides at each end of the muffle, and again a course bricks around the furnace and over each end of the muffle, scoo ing out a little from under each " lintel " brick, if necessary.

Place the second or cupelling muffle, C, in same manner a position over the first, taking care that the communications the two holes providing for the slight and independent draug from the muffles shall not be interfered with by communicat with furnace fire. Again build around the furnace and mu as before, and then lay thereon four rows of brick, betwe which it will be advisable to place thin crossing braces of ho iron. At three bricks above the top muffle, knock a hole 6 in wide and 2 inches deep from the furnace into the chimney, a after providing yourself with a conveniently movable furn cover of iron or fire-stone, it is ready for being slowly dried, use. The fire may be easily lighted in this furnace by putt some small pieces of kindling-wood into the bottom feed-hole F, and then after filling the furnace with charcoal through t more general feeding-hole at the top, to ignite it with a match candle, through the opening, F.

If the draught is naturally bad, it will be better to put a bla ing piece of paper in the hole of the chimney above the muffle so as to start a current of warm air upwards through the fl before lighting the fuel beneath the furnace.

Where a man has to pass through many assays of differ minerals, this will be found a very efficient furnace. For su as require preliminary roasting, the upper and lower muffles ma be both used in the gradually increasing heat of the *early* fire; in the *middle* of the day, the open fire at the top may receive fo crucibles for copper or lead assays, whilst the upper and lowe muffles, C and S, can each receive as many scorifiers, for go and silver assays; or the one muffle may be used for scorifyin and the other for cupelling; or the one for mineral and the oth for bullion assays; or the upper muffle may be regulated in tem perature for lead assays, whilst the under one shall be at a high degree for gold and silver, or copper by the German meth or *twelve* gold and silver assays may be smelted together, as f by crucible in fire, with four in the upper and four in the lowe muffles, by scorifier, and cupelled within the hour, after the furnace is at proper heat; and that, too, by the smallest possib aount of fuel. On one occasion, having everything previously mbered, weighed and fluxed, I passed through, in a similar rnace, thirty-two silver assays, three of lead, and one of copr, in five and a half hours, without assistance; but all ordinary y's works may be brought, by the use of the double muffle and ucible, within the one short period for smelting and cupeltion.

Where much assaying had to be accomplished, I have made a ortable stand, with four rows of compartments, having ten pieon-holes in each row, numbered from 1 to 10.

The bottom row was also denominated A, from 1 to 10.
The second row " " B, from 1 to 10.
The third row " " C, from 1 to 10.
And the fourth row " " D, from 1 to 10.

The first row, A, had sample scoops, numbered from 1 to 10.
The second row, B, had cups, numbered from 1 to 10.
The third row was lined with iron from 1 to 10.
The fourth row contained small watch glasses, from 1 to 10.

Numbered parting flasks reclined at the back, that also anged from 1 to 10, underneath which were alcohol lamps, (as here was no gas,) that contained sufficient alcohol to burn thirty ninutes, the longest boiling time required for the parting of ilver and gold.

Now, in treating eight samples, six of which require to be ssayed for gold and silver, one for lead, and one for copper, you will, after making corresponding notes and numbers upon paper, take six scorifiers, (or six *pairs*, if duplicate check assays, for commercial exactitude, are desired), and number them with red chalk, or with a file, on the exterior, from 1 to 6, and it will also be advisable to smear their inside with red chalk, to prevent adhesion during roasting, and the absorption of the liquid into the scorifier, that would hasten its fusion, and might dissolve holes through the bottom, during the smelting process.

Next take a crucible for the lead assay, and another for the copper, and number them by notches made with a file on their rims. Place these scorifiers and crucibles opposite their respective numbers, to await the time for weighing and fluxing for the smelting process.

A 1—Average from the "Anglo-Saxon" lode at bottom of shaft for *silver*.
A 2—Average from 1000 foot level, north end, for *silver*.
A 3—Average from back of 1000 foot level, No. 1 stope, north for *silver*.
A 4—Average from back of 1000 foot level, No. 3 stope, south for *silver*.
A 5—Average from back of 900 foot level, No. 2 stope, north for *silver*.
A 6—Average from bottom of winze, in 900 foot level, south, fo *silver*.
A 7—Average of stones brought in by Company's prospector, fo *gold and silver*.
A 8—Average of the tailings from last run, for *silver*.
A 9—Average from the "Washington" lode, for *lead*.
A 10—Average from the "Columbia" lode, for *copper*.

Having these samples thus plainly marked, you will next proceed to weigh out from each the proper quantity for assay, and place them in the flat-bottomed iron scoops in row A; then, after adding the desired fluxes, intimately mixed as directed, transfer them to the correspondingly numbered scorifiers or crucibles. Now smelt into the *button*, which, when cleaned, may be placed in the same numbered scoop of B, as the button for cupellation. Cupel, and place in row C. Part by nitric acid in the numbered parting flask at the back of frame, and place the deposit of gold from cupelled button in row D.

Thus, A 7 would receive the properly weighed and fluxed ore for "*Assay*."
B 7 would receive smelted "*Button*."
C 7 would receive the "*Cupelled Button*."
D 7 would receive the "*Deposit*" of parted gold.
The initial letters of rows thus indicating corresponding results, by conformable letters, numbers and operations.

HOW SCORIFICATION FOR GOLD AND SILVER IS PERFORMED.

When concentrated sulphurets of iron or copper contain gold, they should (notwithstanding what has been said in favor of scorification) be mixed with charcoal, and separately roasted and tirred, in a scorifier or crucible, for at least a half-hour, in a moderately hot muffle or open fire, before the actual scorification, f you intend to extract all the gold.

Such samples should be mixed with charcoal, in a well-chalked r red-ochred scorifier; then gradually roasted and stirred with clean iron wire, as the *fire is burning up;* and after this they may be fluxed and scorified like ordinary ores.

For these, as well as for all other ores, 50 grains are as much as the scorifying mode will do justice with; and you may therefore take the 50 grains for roasting or otherwise, unless you prefer to take 37.71 grains, or 29.16, and thereby to avoid all calculation for value and weight in dollars and ounces, as previously described.

A. It may be fused with test lead alone, if desired. To one part of the ore add at least six parts of test lead (lead, comparatively free from gold and silver); mix these intimately together, in the *same scorifier in which it was roasted*, and cover it by a layer of six parts more of lead. *All the silver ores*, and the *ordinary gold ores*, may be mixed with lead, and immediately scorified, by being placed in the hot muffle, according to their numbers, when, after the door is closed, the fire is urged to its greatest heat for fifteen minutes; during this time of first rising temperature, the roasting is partially performed, as the granulated lead melts slowly into numerous globules, which, when falling through the mass, collect and concentrate the precious metals by fusion into one large and central bottom button of lead. In some fusible samples, the smelting is now completed; but it will be always advisable to allow the button of lead to oxidize into litharge, by slightly opening the door of the muffle for a second fifteen minutes, which, by oxidation of the lead into litharge, the gangues are thoroughly fused, whilst at the same time, the size of the button is reduced for cupellation. At the end of this thirty minutes, it will be advisable to stir the contents of each scorifier with a small *hot wire*, suitably bent to a crook: use a new or clean wire for each, and particularly note that the molten slag does not stick to the end, as molasses would, but that it is just as fluid as the molten lead; or the assay lacks sufficient heat for the effectual extraction of the silver and gold.

By the way, the furnace is oftener too cold than too hot; and charcoal cannot make the muffle too hot for this purpose, although coke and stone-coal may do so, and even burn the bottom into holes. (See under 2, for addition of lead, etc., in cupelling.)

After the lead has sufficiently oxidized to encroach from the side of the scorifier, to almost entirely cover the molten lead, the door may be closed for ten minutes, so as to increase the heat, before the scorifiers are emptied into properly shaped and numbered conical moulds; when cold, the buttons must be cleaned, hammered into cubes, and carefully transferred to their correct numbers in row B of the numerical frame.

They are next cupelled as described for crucible, and laid in row C; and, if suspected of containing gold, parted by acid, in the correspondingly numbered flask at the back of frame, and the deposit of gold, after being well washed and thoroughly dried, placed in its numbered watch glass at D.

B. As litharge (the oxide formed from the lead) attacks the scorifier, half as much of borax (or common window glass) as the ore, has been recommended. It also renders some earths much more fusible, but, I think, interferes with the effectual initial roasting of other refractory metallic minerals, by sealing them over before oxidation is effected. As a rule, it is better to use one of them where ores are *not highly charged* with sulphurets of iron or copper.*

In the calculation of value of button in ounces or dollars per ton, see backwards, under third and fourth headings, near the commencement of chapter; and, for parting of silver and gold, forward, under appropriate headings, near the end of this chapter.

Thus, the operator's mind being thoroughly relieved by this system of numbered notes, can devote all his attention to the practical manipulations that must be so closely watched, if correct results are required.

Different men may also take on in shifts, at any stage of the operations, if necessary, without confusion or injury to the work.

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*I prefer to use it only in the last stage after roasting, or to prepare the scorifiers by a previous fusion of a *small amount of borax* therein, to form a sort of surface glaze, as earthenware; which protects the vessel, without hindrance to oxidation, during the roasting stage.

). ASSAYING OF SULPHURETS AND FREE GOLD, BY PRELIMINARY WATER CONCENTRATION, FINISHED BY CRUCIBLE, SCORIFIER, BLOW-PIPE, OR MACHINE, SO AS TO ASCERTAIN HOW MUCH CAN BE OBTAINED BY CHLORIDATION.

This is the mode, *par excellence*, for the practical purpose, of hat can be obtained, after milling, by chloridation. You may ncentrate a *very large quantity* by water, for more correct avege, as described in Chapter III, which by similarity to large ale operations, will thus obtain exactly equal results, and en after drying and roasting the heavy residue, next proceed s follows:

A. First take out the free gold by amalgamation with mercuy, and then treat by roasting and crucible fusion, as described nder No. 5, and deduct just one-tenth of this *fine gold* fire ssay, for what *should be obtained* by chloridation.

To dispense with calculation, you may also refer back to No. 4; r, to renew it here in still plainer terms, to proceed on the folowing basis: As a 2000 pounds avoirdupois ton of gold contains 9166⅔ Troy ounces, it follows that, if any weight is made to ontain this same number of units, each and every one of such nits of weight obtained from a gold sample will be just one, or s many ounces, per ton.

For crucible smelted assay of water concentrated quartz that ontains any amount of sulphurets, etc., you may take the *oneenth* of a Troy grain as a suitable unit to represent one ounce, which is *ten times* the weight of the *smallest white weight*, of the ery superior set of guaranteed weights manufactured by Oerting, of London.) You can make a rough brass weight for yourelf, by putting into one pan of your scales 29166⅔ of these units, that is, 2916 grains and 6⅔ tenths of a grain, or 6 Troy ounces, pennyweight, 12⅔ grains,) and filing your new weight to balnce. Mark this "assay ton," from unit ounce, of the one-tenth grain (or second weight) of Oertling.

Thus, if the button weighed 8 of such weights, it would be, if pure gold, 8 ounces per ton. If 8 and two-tenths, it would be 8 ounces and twice two-tenths, or 4 penny-weights.

If any of the other larger weights should be required, they would simply represent higher decimated quantities, as 28.2 would self-evidently be twenty-eight ounces and four pennyweights; 728.2 would be seven hundred and twenty-eight ounces and fou penny-weights; 6728.2, six thousand, &c.; 36728.2, thirty-si thousand, &c., &c., &c., &c.

The fine gold can be reweighed, after it has been parted, an multiplied by 20.67 for *dollars* per ton. (See "Parting," towards the end of this chapter.)

If you wish to self-calculate for dollars per ton, all that is necessary is to make another "ton weight" of 3771. Troy grains for weighing the sample, when the *same units* will represent *dollars* instead of ounces, and the next smaller weights tenths of a dollar, and when used as a rider on the beam each mark would be one cent, or a tenth of the tenth of a dollar; (but in this case it will be more simple to use the *unit* weight in a more direct rider form, for cents.

B. For scorification of quartz that does not contain more than fifteen per cent. of the heavy sulphurets, a tenth of the last quantity may be taken, and, provided a magnet or magnetized knife-blade is used to extract the metallic iron (broken from the battery, or pestle and mortar), this will generally be within the practical limits of quartz ledges.

In taking this weight, 291.66 grains, (12 pennyweights and $3\frac{2}{3}$ grains, or 377.1 grains for self-calculation in real dollar value,) as a sample, for a scorifying "assay ton," the one-hundredth of a grain, or the smallest white weight of the Oertling balance, will stand for both the "assay ounce" and the "assay dollar."

It may often happen that not more than one and a half per cent. of sulphurets will be found in ledges; so that the largest of these "assay tons" concentrated residues may be even scorified (after precautions taken for iron) without requiring the concentrated sample to be further reduced by roasting and acid.

C. Take, for machine, 160 grains of quartz containing no more than fifteen per cent., or 1600 with even less than one and a half, and after water and perhaps acid concentrations, ridding of metallic iron, drying, and roasting as for the crucible and scorifier, next flux, and cupel by machine, as directed for the assay of silver ores by the machine.

The value is then read under its calculating lever or between s diverging metallic slips, in dollars per ton; at sight, for the 0 grain ton; and by taking off one figure (or decimating it) from e right-hand side of the underlying column, headed by a similar mber to that on the weight, the answer to 1600 grains may be own. See "Little Wonder" for self-calculations without en reading figures.

For blow-pipe assays from sulphurets, 602.7 grains, or the gold ton" bar-weight of the "Little Wonder" may be taken, d the sample, after it has been sufficiently lessened in quantity y roasting, acid and water concentrations, may then be duly elted, after the manner described for silver.

So as to remove the least chance for errors, these several mounts and values may still be more plainly shown by the fol- owing short tables, which are adapted to every mode of assay:

If you have made a crucible assay for silver from 377.1 *grains,* s *weighed with any decimal Troy weights, and have the button xactly balanced by weights in the pan:*

Each and every *unit* of $\frac{1}{100}$ grain, (.01) (the smallest weight) will be=$1. per ton.
Each and every $\frac{1}{10}$ grain, (.1) ....will be=$10. per ton.
" " 1. grain, (1.) ....will be=$100. per ton.
" " 10. grains, (10.) ....will be=$1000. per ton.
" " 100. grains, (100.)................will be=$10,000. per ton.

In the above example the *cents* are read by cutting and bending a piece of silk or cotton hread to a V shaped *rider weight,* exactly equal to the unit, so that it may be moved to alance upon the decimated beam, for this express purpose.

If you have made a scorified assay for silver from 37.71 *grains,* (37 *grains and* 71 *hundredths,*) *and the button is balanced by weights in the pan:*

Each and every *unit* of $\frac{1}{100}$ grain (.01) (or the smallest weight) will be=$10. per ton.
Each and every $\frac{1}{10}$ grain (.1) ....will be=$100. per ton.
" " 1. grain (1.) ....will be=$1,000. per ton.
" " 10. grains (10.) ....will be=$10,000. per ton.

In this case, the *rider unit,* or $\frac{1}{100}$ grain, gives the *dollars and cents* when balanced upon the decimated beam.

If you have made a blow-pipe assay for silver from 3.771 *grains,* (3 *grains and* 771 *thousandths,*) *and the button is balanced by weights in the pan:*

Each and every *unit* of $\frac{1}{100}$ grain (.01) (or the smallest weight) will be=$100. per ton.
Each and every $\frac{1}{10}$ grain (.1) .... will be=$1,000. per ton.
" " 1. grain (1.) ....will be=$10,000. per ton.

Here the *rider unit* will show that each hundredth mark upon the beam *is equal to* $1.

If you require ounce results, take the corresponding assay ton, in ounces, as fully explained; and the above figures will then give ounces per ton, for both silver and gold.

If gold is required in dollars per ton, it may be found in two ways: the first by multiplying the weights of the separately weighed sponges of gold from either of the above results by 16, *and then simply valuing by such new weights or figures as if they were silver; and the second, by taking a gold "assay ton" of* 16 *times the weight of either of these quantities, and after water concentration, to smelt the small residue by either crucible, scorifier or blow-pipe, as most convenient, and the same tabulated values will be also correct for gold.**

11. ASSAYING BY AMALGAMATING WITH MERCURY, AND SMELTING BY CRUCIBLE, SCORIFIER, BLOW-PIPE OR MACHINE, TO KNOW WHAT PROPORTION OF GOLD CAN BE OBTAINED BY AMALGAMATION.

This is also an excellent and sufficiently correct method for ascertaining how much gold may be obtained by battery, pan, arrastra, or barrel amalgamations; and these (No. 10 and No. 11) methods also show, when combined, how much there is really in the rock, how much can be extracted by ordinary milling, and also, by their difference, what the sulphurets are worth.

Take either of the largest quantities named under the last headings, as ounces or dollars are desired, then concentrate, and place the heavy residue into an iron mortar, with a cupful of water. Next add about six ounces of well-strained and cleaned mercury, and stir, without grinding too much, for about two hours, (as the object is only to amalgamate the free gold,) when you may leave it stand over night. Stir for a few minutes in the morning, with the mortar full of water; pour off, and carefully strain the mercury through a compact chamois or buckskin. If the rock is very poor for gold, it will be convenient to add about one grain of zinc, or fine silver, to amalgamate with the mercury, so as to obtain a more tangible body of amalgam, for straining and fire treatment.

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*I have found it still more convenient when using these self-calculating quantities for gold, to take say the 602.7 quantity, and weigh out one, two, three or more of such "assay tons," just as long as the *quantity* pulverized will permit repetition; and when finally valuing the result, to simply divide by the number of times taken.

Sublime the amalgam *in a crucible*, either in the fire or before e machine's roasting furnace, to pass off the mercury, etc. ext flux and smelt by crucible, scorifier, blow-pipe or machine, ke the silver assays; and then part, if necessary, by nitric acid nd ascertain its value as before, by unit weight system. Be areful to avoid the fumes from mercury.

In this instance, the gold being but little and free, the mahine equals the scorifier and crucible for quantity, but requires he assistance of their weighing scales; it, however, might have een performed for the *three* by the calculating lever of machine, f, instead of the "assay ton" being 29166 grains, it had been ither 16000, 1600, or 160 grains, as required to conform to the rinciple of its calculating lever.

If the 160 had been taken, the table would have been read in ollars per ton at sight.

If 1600, the right-hand figure should have been cut off or ecimated.

If 16000, two right-hand figures, etc.

12. FREE GOLD IN QUARTZ MAY BE READILY ASSAYED BY PRACTICAL MEN, WITH ORDINARY TOOLS, AS FOLLOWS:

A. Concentrate the finely pulverized "assay ton" of 3771. grains, or about 7 Troy ounces, 17 pennyweights, very carefully, by water, in the manner described in Chapter III, Section III.

If very close results are required, such as will not, however, be realized on the large scale, first shake the sample in a close bottle, to thoroughly wet the ore and settle the gold which might otherwise float away in first water. After the iron has been extracted from the heavy concentration beneath the water, by a magnetized knife-blade or magnet, pour off and dry the residue which also contains the gold, by placing the basin, saucer, or plate, over any convenient pot of boiling water, or any warm surface, lamp or fire; and when quite dry, it may be swept into a suitable vessel for roasting.

Roast this heavy residue very thoroughly, then pulverize again and dissolve away all but the gold in nitric acid. Pour off the nitric acid, and after the gold has been well washed and dried, it may be transferred to a carefully balanced scale-pan or paper, as described under No. 14, for the most exact weighing of small quantities. Each tenth of a grain thus obtained will represent one ounce per 2000 pounds ton of this alloy of gold, silver, copper, etc. If you have no tenth grain, divide one end of the lever into ten parts, and make a rider grain weight, by bending a small piece of wire, or dry twine, into the shape of a horse-shoe, when each mark will represent a tenth grain, and one ounce per ton. If your scale is a very common one, having industry and patience you may take ten times the quantity of this "assay ton," and every grain will represent either a dollar or an ounce, as the proper assay ton quantity is taken.

B. If it be desired to have a button of gold from this residue, by fusion with machine, place the fine gold in one of the prepared charcoal supports, cover with a thin layer of borax glass, this similarly again by about 20 grains of test lead, and, after lowering the suspended covering of charcoal as close down over the assay as practicable, smelt, by carefully increased blast, into auriferous lead, and cupel as described in the fifteenth mode, for the silver assay, by machine. This will still be an alloy of the pure metals, gold and silver, which can be *approximated by the practical eye for carat value;* but if gold is correctly required, it must be parted from silver, &c., as described toward the end of this chapter, by acids.

C. Amalgamate with mercury, then slowly roast or retort, and smelt as under No. 11; with blow-pipe or by machine, as above.

13. GOLD AND SILVER ASSAYING WITH COMMON BLOW-PIPE.

By the elaborate methods described in books.

The following has been the method used in past times, which is here described in as few words as possible, so that the reader may know, by simple comparison, whether he will adopt this or the new methods as previously described at pages 208, 209, 210 and 211.

Pulverize and mix your sample with even more care than before; take about five grains therefrom, which place in an agate mortar, or a common cup or saucer, and grind it still finer with the pestle, or between small flat stones, to an impalpable powder. Next weigh, from the mortar, cup or saucer, just one grain for the assay (which is as much as the common blow-pipe will successfully reduce by this method); with this most intimately mix its weight of borax *glass*, and six times its weight of test lead.*

Prepare a cartridge—or, better, a few dozen spare ones—by cutting oblong strips, 1¾ inches long by 1 inch wide, from soft *bulbous* letter-paper, which then soak in a saturated solution of carbonate of soda; after these strips become dry, roll them on the butt-end of a common pencil, of about a quarter inch diameter, in such a way that sufficient may also overlap its end to form the bottom of cartridge; moisten the last folds of the side and bottom with flour paste; and take off, to dry for use. Transfer this (one grain) *fluxed and leaded sample* to an empty rifle cartridge, sewing thimble, or more suitable scoop, if you have it, and mix it thoroughly together with a pin or other small, smooth, and convenient stick. Select a good piece of charcoal (willow and white pine are best), which must be free from cracks, and of about the size and shape of the largest new cork for a wine bottle. The willow coal is most readily shaped by simply cutting into lengths from the branch as it grew. Into each end (so that it may serve twice) drill, with a suitably sized charcoal borer, a sharp knife, or sharpened piece of hard-wood, a central hole, a *little larger* than the prepared paper cartridge, and a quarter of an inch deep; place this cartridge in it, and when it is thus supported in the charcoal, carefully sweep the sample, with a camel-hair brush, therein; add 3 grains more of test lead, on the top, and fold the surplus paper well down over the enclosed sample, for better resistance of the first effects of the blast, during smelting.

Next learn to blow the whole of the flame of the candle or lamp before the pipe, *without any cessation*, for fifteen minutes, and, when you can do this efficiently—which practice alone can realize—you may proceed with the assay as follows.

Take into the left hand the charcoal support, which contains the cartridge and fluxed sample, and surround it by the thumb and all the fingers, in such a manner that the assay may be held *about 20° diagonally*, whilst it is being also *turned by the fingers on its own axis*, as most desirable. This will also require practice, before you will be able to effect all the necessary movements with proper precision and certainty.

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*For about thirty years of my earlier practical life I had used the method which I am now endeavoring to explain, and therefore am fully educated as to its difficulties and defects.

The new methods described in the several pages from 208 to 212, for assaying gold, silver, and lead, are not only more easily performed by amateurs, but will treat very much larger quantities, and when water concentration is also used to prepare large samples before smelting for the gold assay and the "Little Wonder" is employed for weighing and calculating the various buttons, they are surpassingly effective.

When these can be adroitly performed, closely trim your olive-oil lamp, so that no stray fibers shall cause imperfect combustion, and rob the flame of much heat; this being done, place the lamp at suitable and convenient distance and height before you, so that all the necessary manipulations may be readily performed.

Now, blow the blue flame, with a gentle pressure, upon the horizontally held assay, until the upper lead melts and becomes safely ensconced in the molten slag; after taking a rest, *gradually incline* the assay at an angle of about 20° towards the nozzle, and *enclose it in*, or *cover it by*, the point of the *whole mass* of the yellow flame, so that the ore may be *reduced* as quickly as possible to metal, by this exclusion of atmospheric oxygen, and the greater heat thus produced.

During this reducing stage, three things must be more particularly noticed.

1. That the pressure is neither too much nor too little, but such as is seen to be, by bright combustion and fluidity, most suitable for extremely high temperature.

2. That the lead is *red hot*, and travels freely *around* and *through* the mass of *effervescing and mobile* slag, at your pleasure, by suitable twist and inclination of the support.

3. Towards the close of this smelting operation (which generally requires from ten to fifteen minutes), you should more particularly observe that the scoria becomes "orbicular;" or, more intelligibly, that the molten lead button is partially enclosed by the *mobile and supple* slag, as the eye by its lid; for such is the final appearance of good smelting.

This, when cold, may be separated and cleaned, by being enclosed in a small piece of rag, or a few folds of paper, which safely retains the whole and most effectually separates the lead from its slag, when subjected to a few blows from a light hammer. The button of alloy must be now hammered into a cube, and further cleaned with a hard brush, for more speedy cupellation.

The method for cupellation of the button, as first used by the Swedish blow-pipists, and since too highly recommended by modern writers, is that of ramming moistened bone-ash into small but comparatively thick and heavy iron moulds, by a suitably shaped convexed steel pestle, and then, after the whole has been dried, it is placed within the four-clawed end of a round handle, which by being transversely flattened at the other end, it also serves as a sufficiently secure base for standing upon the table when not in actual use.

The button being placed thereon, is held by the left hand in proper position before the oxydizing flame, which is then played partly on the iron to create a supposed reservoir of heat, (?) and also in front of the button for its oxidation. This method is, however, more *convenient* for mechanical manipulation than *effectual* in use.

See a much better mode on pages 209 and 210, under headings 10, 11 and 12.

This is next warmed before the blow-pipe's flame to *redness*, and the lead being put thereon, after it is rendered *red hot*, or *molten*, in the reducing flame, it is held *beyond the tip* of the small and *conical blue flame*, for oxidation of the lead and other base metals, and consequent purification of the precious metals, gold and silver.

This operation is completed when the peculiar appearance of the button of silver or gold, called "brightening," is exhibited, which had better be practically studied before blow-pipe, on small, *known sized*, silver and gold buttons, purposely *alloyed with lead* for this particularly important purpose. (See "Cupellation of Button," from crucible assay of gold and silver, in Example 2, of this chapter, for its appearance.)

This method is altogether worthless for direct gold assays, as they make no suggestions for the preliminary concentration of much larger quantities, either by water, or by roasting, acids and water; as given in the new and exceedingly practical and valuable mode at page 211, for really assaying gold by blow-pipe, and at the several places in the water concentration chapters for practical men.

ASSAYING OF GOLD AND SILVER BULLION BY BLOW-PIPE, FOR VALUE PER TON, OR THOUSANDTHS FINE.

The assaying of bullion is much more simple than mineral assays from rock, as all that is required is to take a certain convenient quantity of the metal for the mode adopted and purpose intended in calculation, and to cupel to purity by the addition of sufficient test lead. For blow-pipe assays, after the silver and gold are parted in the manner explained near the end of this chapter,—if for value in silver per ton, take 3 Troy grains and 771 decimals of a grain (3.771), and the weights will show the value, without calculation, as already explained; or, take the S-shaped weight of the "Little Wonder," as used for silver assays, and read its value in same manner as for the silver assay of mineral. For gold, first value it as for silver, either by the weights or the "Little Wonder," and multiply it by 16 for its value in gold. Or you may take any quantity within the capabilities of the blow-pipe, and figure out results for value per ton and thousand, as you may desire; and cupel as recommended at pages 209 and 210. See also under Heading 17.

14. WEIGHING, AND CALCULATING THE VALUES, OF SMALL BUTTONS.

However difficult the smelting and cupelling manipulations for the assay of gold and silver by the common blow-pipe may be, that of weighing the resultant button is even more so; and as it has not been previously explained, it is therefore more eminently worthy of some special observations regarding the best means for surmounting these practical difficulties.

The Berzelian glass-cased portable balance is, as regards regular beam and pans, the most convenient and susceptible for these minute weighings. The lever is poised on a very delicate knife-edged fulcrum, which rests on jewels that are supported upon and rocked, by a pendulous cradle; and thus, under all circumstances, it settles in vertical position. This pendulous cradle (which is its best characteristic) supports the whole scales, and is attached to, and suspended from, a square bar and frame, that, when moved by a kind of miniature barrel winch and silk thread, slides truly in a suitable socket, and steadily hoists or lowers the pans off from, or upon the bed-plate, as required in the operation of weighing.

The warranted weights made by Oertling, of London, are most reliable and convenient, which, by ranging and decimating from 1000 grains, by 100 grains, 10 grains, and 1 grain, thence still smaller to one-tenth grain and one-hundredth of a grain, afford every facility for *varying the required quantity* for either the water, chemical, volumetric, crucible, scorifier, or blow-pipe assays; as well as their respective advantages for calculations by every necessary decimal division.

To weigh a silver or gold button that has been produced from a one-grain sample, it will be advisable to prepare, and examine the action, of such a new apparatus, as to its susceptibility; which may be done in the following manner. Take out the beam, lay it on a board, and carefully mark its right half, with a square and compass, into ten right-angled equal parts, by scratching its nearer edge and side with a needle's point; and these again into tenths, by shorter and less distinct lines; and its left-hand side should be also divided into twenty parts for pennyweights.*

Replace the lever into its cradle, and make a weight from a very small and dry white silk or cotton thread, so that it may exactly equal the smallest of the Oertling white aluminium weights (one-hundredth of a grain); bend this thread weight to the shape of a V, so that it can be used as a rider.

Fix permanently a brass or tin-plate tube, containing a lens, to the upper part of the glass case, in such a manner that you can distinctly read the magnified motions of the graduated ivory upon the cradle pendulum, and the pendulous pointer from the beam, to these degrees, both when the glass door of the case is open and closed.

Elevate your scales by the thumb-tackle, so that the pans may be about one-eighth of an inch above the bottom of the case, and scratch a mark on the square bar that elevates the scales, so that they may always be raised to the same height. These being finished, you may now drill with a brad-awl, two holes in the bottom of the case, on the nearer side of each pan, and turn two pieces of wire into ⊏ shapes, so that the limbs of the ⊏ being placed downwards, they may be forced into these holes, until the back or body of the letters shall form transverse bridges in front of the scale pans, and about three-fourths of an inch high from the bottom of the case, for greater convenience in dropping small weights and buttons (which are frequently retained by cohesive attraction), by *tapping* the forceps thereon.

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* This can be most readily and correctly accomplished by drilling a hole, about three inches from the left-hand *straight* edge of a suitably sized board, to snugly receive the knife-edged central axis of lever; the beam being placed thereon, it should then be carefully fenced in, and firmly secured by small tacks, in a position just parallel to the edge of the drawing-board. Next take one side of an ordinary cigar box, and, after pasting a white sheet of paper upon it, mark, by cross lines, the exact positions of the center, and end knives, of balance lever, and divide the one end into equal tenths, and the other into twenty parts; and then, by other lines, divide across the first end, intervening series of tenths of these first cross lines, and the last into twenty-four parts (for reasons described), and, assisted by the square, and a needle for pegging position, then finally scratch with a fine needle corresponding marks on the *beam itself*, so that they may be distinctly seen when using the rider.

You may also break a piece, about two inches long, from off the *end* of an old clock's main-spring, on which the eye remains, and force the plain thin end in the joint formed by the wood at the top of the glass case, so that the bow at the other end may gently spring to and hold the glass door, when it is necessary to be kept thus elevated. This will be much better than the silken loop and brass pin, which are now supplied with the case for this purpose.

Being thus accommodated with facilities, you had better sit before the instrument, and study the natural motions of the pointer, and also the pendulous cradle, that carries the graduated ivory scale; and notice more particularly that their oscillations should be long continued, and quite gradually lessen to a very short movement, before final settlement. Now take a piece of very thin glazed paper, and cut a strip therefrom of about the width of a pin, and transversely cut from this strip other very short pieces, to bring the beam to balance by placing them in either pan, as may be required. Learn to read these magnified minute motions scrupulously exact, and be sure that the scales are properly balanced, before weighing any very small quantity, for value. I prefer using two unglazed paper pans, just *slightly* turned up at one side, like angle iron, and keep cutting from the one or the other, as required for balancing:

The turned-up part serves for more convenient handling by forceps, as well as a secure side fence for stopping gold sponges from hopping over the paper when transferred from the drying dish for being weighed.

(See bullion assays and parting gold and silver, near the end of this chapter.)

Having advanced thus far, cut off from the same thread of which the rider was made, a piece of only one-fifth its length, and, observing that the pointer is still straight with the mark, drop it into one of the pans, without lowering them, by gently tapping the forceps on the transverse wire bridge in front.

If this will turn the beam so that it can be seen by the pointer, it may be sufficiently near for your general purposes in the silver assay; but if it does not, you may make the beam more susceptible by carefully operating thereon, *at your own risk*, as follows:

Unhook the pans from both ends of the main lever, and *very gradually* file or scrape the pendulous steel-pointer, (which lessens the distance between the centers of gravity and floatation,) which is, however, a somewhat dangerous operation, for it may, when overdone, render the balance wild and irregular in settling; this, however, may be again rectified by putting on a small silver or gold globule at a short distance above the lower end of the pointer. The beam should then vibrate nine strokes per minute.

I have such a balance, prepared in this exact manner, that turns with half this quantity, (the one-ten-thousandth of a grain, which represents $3.77 per ton, on one-grain assays,) when balanced by the thread rider, and moved but a one-hundredth mark on the lever.

The balancing by small pieces of paper is a slow and tedious affair, which I have avoided by fixing a weak magnetic needle in a suitable side position, at the proper height in the case; so horizontally swiveled on central and side pivots, that the slight positive and negative powers may be applied at varying distances, to attract or repel the steel pendulum as required. It is prompt, effective and exact; as well as a great comfort in use.

Having ascertained that your scales are sufficiently delicate, you may now take the button from the bone-ash, by holding it on edge in a clean saucer or plate, (which is much better than paper, because the latter springs the button away, and it is often thus lost,) and then gently remove it by a judicious *twist* with a pen-knife's sharp point, when placed just beneath one side. After the button is cleaned to your satisfaction, which should be examined with a magnifying glass, move the plate or saucer close to the scale-box, see that the beam is still balanced, and take the button in the inverted forceps at an eighth of an inch back from its point, and carefully transfer it with the right hand to the left-hand scale-pan, by tapping *very lightly* on the cross-bar in front. The sample and resulting button should be weighed at the same end, so that unequal beams may not cause error.

Now place, with the forceps, the white thread rider on the other (graduated) end of lever, without jostling the lever in the slightest degree, and move it until the pointer again indicates exact equilibrium, as before. This must be done with the pans *suspended all the while*, for very small buttons, as the smallest movement, or the slightest jar during the rise and fall, by changing the point of rest, would destroy equipoise.

It will be always advisable to at least repeat the balancing and weighing, and lastly to check, by placing the rider on this supposed truthful position first, and then to merely drop the button into the suspended pan, for positive results.

If the button should weigh less than when this rider is on the first tenth mark, the beam may be first *balanced* with the *rider on this mark*, and the button being then dropped into the pan, its weight will be more easily and correctly read, by counting only the *additional length* that the rider is *moved outwards*, to re-balance it.

To calculate the value of such a button, when obtained from a one-grain assay, let one-tenth the weight of this thread rider, which is the one-thousandth of the one grain, stand for an unit of calculation, as previously explained, which may be either directly multiplied by 29.16 for ounces, or by 37.7 for dollars per 2000 pounds ton; or you may multiply this weight, as obtained from 1000 such units, by 2, to show what a double smelting, or two half-tons, would have given, which of course would be exactly the same as that from the 2000 or real assay ton; this, by being then multiplied by its multipliers of 14.58 for ounces, and 18.85 for dollars, will give the same amounts. When this thread *rider* of the one-hundredth of a grain is used, the *unit* will therefore be the first mark from the center of the beam, for this will be just a tenth the weight that the rider would have been in the pan.

Having made yourself thoroughly certain of what constitutes the unit, or first whole number, for the different quantities taken from time to time for assay, by following it up and down from the nominal ton, you may refer to the following table of multipliers, which, as you will see, is founded on the foregoing explanations.

If 2000 grains, 200 grains, 20 grains, or 2 grains, be taken for the. 2000 pounds assay ton, each unit or pound (of two-thousandths of the weight taken) must be multiplied by 14.58 for *ounces* per ton of *gold and silver*, and by 18.85 for dollars in silver, and by 301.36 for dollars in gold.

The multiplier for the coin value of any nation may also be found by simply multiplying any *unit* of such ton weight by the desired money it will realize.

Where the ton is not capable of direct decimation, or variable, such as the English, it is better to take an amount of *units* equal to it, as 2240, 2352, or 2300, as the case may require, of such assay pound units, for the assay ton, and use the same multipliers as before.

These multipliers may be then tabled as follows, to suit the required fractional quantities taken for the different methods of assay:

For 1 assay ton, (as the representative of any real ton,) the *assay pound* x 14.58 gives the ounces of gold and silver per ton.
For ½ assay ton, the *assay pound* x 29.16 gives the ounces of gold and silver per ton.
For ¼ assay ton, the *assay pound* x 58.32 gives the ounces of gold and silver per ton.

For 1 assay ton, (as the representative of any real ton,) the *assay pound* x 18.85 gives dollars in silver, and x 301.36 dollars in gold.
For ½ assay ton, the *assay pound* x 37.7 gives dollars in silver, and x 602.73 dollars in gold.
For ¼ assay ton, the *assay pound* x 75.4 gives dollars in silver, and x 1205.46 dollars in gold.

These multipliers will be all that you will require for these necessary and general quantities; and also for *any of the tons*, if the corresponding number of *assay pound units* are taken that *constitutes such different assay tons*, when decimated weights are used.

In addition to the foregoing remarks, you should also know, by the weights themselves, whether you are taking a ton, a half-ton, or a quarter-ton quantity. This may be easily seen by noticing these three simple facts: if the first figure of the quantity is a 2, it will be a *ton*, as 2000, 200, 20, and 2; if the first figure is 1, it will be a *half* ton, as 1000, 100, 10, and 1; if the first figure is 5, it will be a quarter-ton, as 500, 50, and 5. If you have taken the half or quarter, always look upwards for the ton, by searching for the next higher *and first figure*, of 2, as explained.

I have covered considerable space to explain these technicalities to the amateur, because he is supposed to know but little of these matters; and hope that I have succeeded in rendering them sufficiently clear to his view for all practical purposes. He must not forget that the principle of calculation hinges entirely on the assay ton and assay pound, say 2000 against 1; the latter being the unit for calculation; and that where the above fractions of the tons are used, the same unit is retained, and consequently the multiplier must in all cases be either that used for the full ton, or be multiplied by the *denominator* of the *fraction* of ton taken, as that of the last, for the scorifier, where the first, multiplied by 4, equals the last multiplier.

Or it may be done for *any quantity*, as a compound fraction, by inverse proportion, thus: If 2000 pounds require the multiplier of 14.58 for ounces per this ton, what multiplier will 500, *or any other quantity*, require, to ascertain its value per ton in ounces? It will require a larger multiplier, as already shown, so that $\frac{2000x14.58}{500}=58.32$; so, for dollars, $\frac{2000x18.85}{500}=75.4$.

You will see that any number of such units may be taken, when of suitable weight for making an assay ton from the correct number of such, to suit the method of assay. For instance, the crucible assay may be made from 2000 grains, or 200 grains, or 20 grains, because you can very readily use different size crucibles and divide into the 2000 units in each case; whilst 2 grains can be as easily divided, for the principle of figuring, in the half-ton taken for the one-grain blow-pipe assay, when calculated by the rider, in manner explained.

English readers may take any one of the tons, as 2240 pounds, for assay ton, and any suitable unit thereof for assay pound, to suit the kind of assay, so that the unit or number of units, or assay pounds, realized therefrom, being multiplied by 14.58 (the number of Troy ounces to the avoirdupois pound), the Troy ounces and their money value may be also known in £, s. d. by multiplying the ounces per ton by their coin value, or the rates given for fine gold and silver, at the time and place. (See heading 4, for suitable assay ton, for self-calculation, and sub-division for dollars and cents, or ounces and pennyweights, by rider on suitably marked beam.)

So may the value of any one ton be as promptly obtained, by proportion, from any known value of another; as, supposing the 2000 pounds American ton yielded at the rate of 3.12 ounces, the 2240 pounds, or any other English ton's value, may be known thus: The 3.12 ounces, multiplied by the 2240, and divided by the 2000, will show the corresponding yield of such a ton to be 3.494 ounces, etc.

When in comfortable quarters, with good tools, a skilled and experienced operator will always find the *common blow-pipe* most excellent for *testing*, and, *with very superior scales*, even approximate *assaying of silver*, as its ores can be *mixed to a fair average;* but, for *gold*, which is always so *irregularly deposited* in *metallic nugget* form, it is *most absurdly ridiculous* to smelt but *one grain*, which might or might not have any in it, for *average assay information*, even were it possible to weigh and value such *minute* resultant buttons. It is, however, very correct for the thousandths fine of both gold and silver bullion.

(See my concentration methods by roasting, acids and water, combined with final smelting of the very small residue by blowpipe; and also the weighing and self-valuing of button by "Little Wonder."

The valuation for percentage of base metal assays is very simple, as either exactly the 100 grains may be taken for sample, when the weight of resultant button will give it at once; or 50, or 25, or 20 grains may be treated, and the percentage got by then multiplying such buttons by the conformable figures 2, or 4, or 5. Thus, if a button obtained from a 25 grain sample weighed 5.5 grains, this multiplied by 4 would give the united result from four such samples, or 22. from 100, and its percentage.

Samples for thousandths fine *may* be made exactly 1000 by carefully cutting and filing; but it is better to take the chips or granulations so as to be only *somewhat near*, and either over or under some nominal thousand, as 1000, 100, 10, or 1 grain, and to calculate the result, after cupellation, by proportion: thus, if 1120 grains yield 901.2, the 1000 would yield less, and therefore 901.2 multiplied by 1000 and divided by 1120, will give the thousandths fine: or if less than the thousand had been taken, say 941.3, and it yielded of pure silver or gold 807.6, the 1000 would have yielded more, and then the proportion would be known, by multiplying the result, or the 807.6, by 1000 and dividing by the quantity taken of 941.3.

It may be stated in still plainer terms that *the thousandths fine can be in all cases found by multiplying the weight of the purified metal by* 1000, *and dividing by that taken for sample.*

See "Little Wonder" self-calculating sample and button-weigher at page 202 for dollars per ton and thousandths fine of gold and silver, as well as percentage of base metals; and Heading 25 near the end of chapter for parting gold from silver, &c.

15. THE ASSAYING OF SILVER BY DIRECT SMELTING AND CUPELLATION, WITH THE EXPLORER'S "WEE PET" MACHINE.

Erect the machine for general purposes, as described at page 170, Chapter IV, on Discrimination, and as shown at page 307.

Pulverize and faithfully prepare the sample, as described in Chapter I of Section III; so that you may obtain as perfect an average as possible, and if the sample is from a district that yields chloride, or metallic silver, the upper side of the sieve must be closely observed for flattened disks, as there more particularly described, so as to conduct your operations accordingly.

A. Place the machine in a level position upon the ground, a rock, or table, with the weighing and calculating lever transversely before you.* Take the weight-box, marked W, Figure 29, from its compartment in the flux-box, and, keeping the *marked* side on top, slide off the brass fasteners, F F; then, whilst the bottom *rests on the table*, next open its lid, just as seen at the lower part of the figure, so that it may expose the weights and still rest securely in position.

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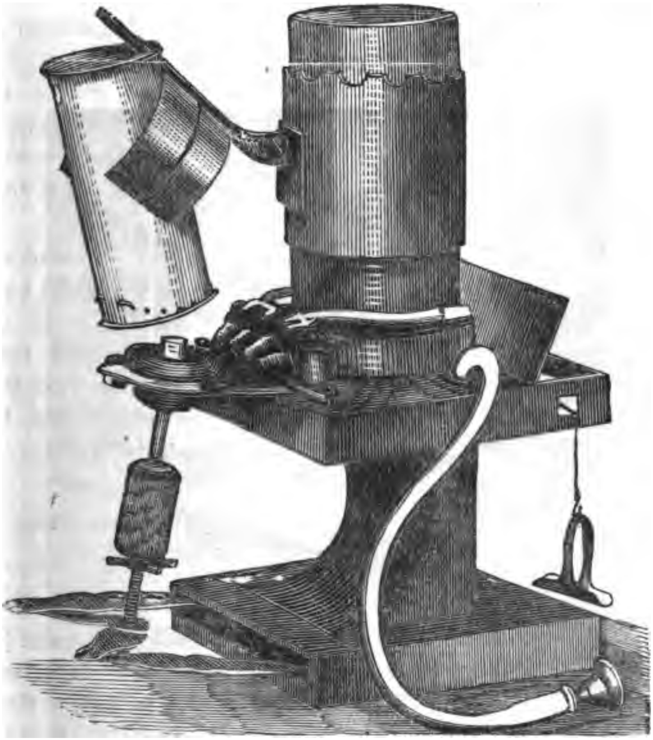
* This and the other eighteen novelties of the "Wee Pet" Assaying Machine have been secured by U. S. Patent, dated 7th September, 1869.

Figure 28.



B. Now take the tubular weighing lever out, and place the knife-edged fulcrum on its glass supports, so that the short end may pass out with its hook at the right-hand, whilst the long end slightly protrudes its pointer through the left-hand side of box.

C. Square the bow of the small scoop, and hang it to the crook, suspended beneath the short end of lever (as in Fig. 28).

D. Close down the cover of the tool-chest, that lies under the scales, and wipe its upper side perfectly clean, so that it may form a bed-plate for the pan, when weighing.

E. Take the *balancing* and *assay weight*, marked A, that equals 10 grains and lies on the left side of the weight-box, in your forceps, and lay it on the cleaned lid of the tool-chest, with one mon blow-pipe assay of one grain; when the lever again balances, the weight of ore will equal A, and is also 10 grains. This may now be either treated by my method somewhat after the manner of scorification, as K 1; or as under heading K 2, by cartridge, etc.

K 1. Place the one weighing of 10 grains of ore in the moulded or whittled charcoal support, and three balancings, or 30 grains, of litharge therewith, which mix intimately together, and then cover the whole with six weighings, or 60 grains, of test lead, and smelt with a gradually increased blast for from fifteen to twenty minutes, (as directed under headings T, U, V, W,) and then refine the button as instructed under heading Y (for cupellation).

In this method, which is much more simple and requires no paper cartridge, there are four effects produced:

1. The mineral is cemented, and fused with litharge, by a *gentle blast*, which effectually prevents loss.

2. It is first oxidized and finally smelted at full heat into alloy with the lead.

3. This alloy is partially oxidized into litharge, which forms a very fusible slag with the matrices, and reduces the weight of lead for cupellation.

4. It is cupelled and refined on bone-ash, as under Y.

In *fusible non-refractory silver and silver-lead ores*, 20 grains may be treated, by this much more capacious method, when aided by these very heavy and compact fluxes, which has also other advantages over the scorifier of the concentrating effects of the flame on every part of the assay, as it is constantly turned round, so as to cause the lead button to travel through the mass, and collect every particle of silver and gold that may be therein contained.

K 2. Take from the side chest with the left hand, one of the duly fluxed and pasted paper cartridges; then after weighing 10 grains of ore, as before, unhook the scoop with the right hand, and, with the cartridge in a horizontal position, first enter the scoop therein, and then, by elevating the former, and tapping the latter with the finger, all of its contents may be effectually dropped and brushed in.

L. Weigh the same weight (10 grains) of borax glass, from the right-hand compartment of flux-box, and drop it in similar manner thereon.

M. Lastly, add to these, six balancings (60 grains) of test lead, and two weighings (20 grains) of litharge.

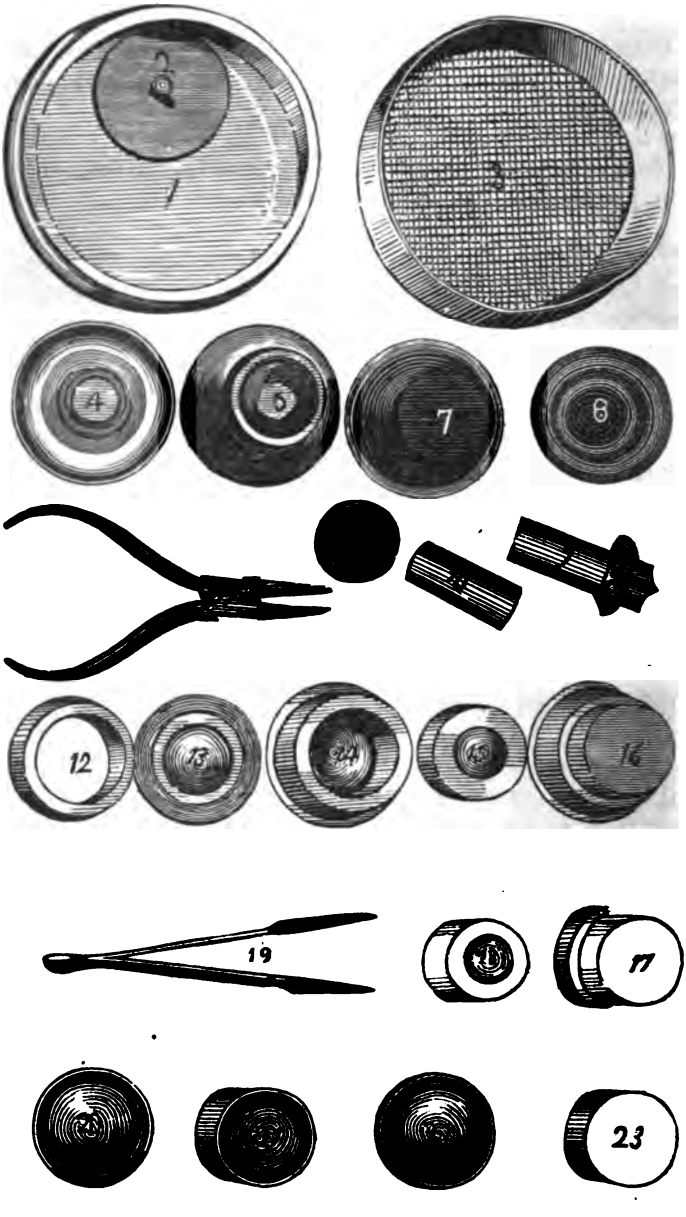
N. Intimately mix these together, by simply stopping its mouth under the thumb, and shaking the whole contents between the thumb and finger, as you would a small bottle of medicine.

O. Fold the surplus paper snugly down over the ore, place it in the charcoal support, with the thick folds towards you, and it is ready for being smelted.

P. These cartridges are made by being first cut into oblong strips, four inches long by one and a half inch wide, from tough and somewhat bulbous brown paper, such as is used by miners for making blasting cartridges, when sinking wet shafts: they must be then *soaked for an hour* in water that has been *saturated with carbonate of soda*, (with as much of the carbonate of soda as the water will take into solution,) and to which *as much sugar has been added after this saturation* as the water will *then liquefy*. They are next warmed in the sun or by a fire, and when quite dry, folded on the handle-end of brass charcoal borer (Figure 30, Number 9); simultaneously turned over its end, and firmly pasted with starch or flour, and withdrawn (as Number 10), again dried, and stored for use, when required.

Q. Take one of the *moulded charcoal supports*, or an exactly similar one, that has been "whittled" or filed, from a good and solid piece of charcoal, to suit the bell-shaped support; and shaped, on its upper side, with the appropriate charcoal borer (Number 9, alluded to under paragraph P), and place either of these in the bell-cup, with the *machine* in the position shown in Figure 28.

Figure 30.



R. These assay supports may be moulded from the following composition:

Finely pulverized charcoal	60	table-spoonfuls.
Carbonate of soda	4	"
Common *store* borax (not borax glass)	2	"
Sugar or molasses	2	"
Rice flour, corn or wheat starch	1	"

Water just sufficient to mix for moulding.

Take a baking-dish or prospecting-pan, and first place therein say 20 spoonfuls of water; into this water throw 4 of carbonate of soda, 2 of commercial borax, and 2 of sugar or molasses, all measured to the brim, by being struck off level by a knife; warm over a fire, stir until the ingredients are dissolved; then add the rice flour, and again stir until the liquid boils and becomes, from the softening of the rice flour, somewhat paste-like. Take it from the fire, and, after it is cold, add the 60 table-spoonfuls of charcoal; then mix and well knead it, as you would dough for bread. It is sufficiently wet when it just holds together after pressure within the hand.

S. Take the bottomless bell-cup (which is of similar size and shape to the assay-supporting holder) from the long tool-chest; place it on the thin brass bed-plate Number 4, that resembles the shape of the top of assay support or coal (like Number 5); then fill it tightly with the composition, by pressure of the thumb and a small ramming-stick, and insert on the top of the moulded coal the small cheese-shaped brass disk (Number 6); after ramming it down fair and square with the top of external mould, rest your right thumb vertically thereon, then raise the bell-cup mould with a twist up over the thumb, and after lifting your right thumb away from, take off this brass covering also by a twisting motion. Invert the coal and bed-plate (Number 7) into the left hand, and carefully separate, by a steady circular movement of the right hand, the brass bed-plate therefrom; and lastly, after placing them on a stone, to dry slowly by a fire, you should sift upon the assaying side, a little dry carbonate of soda: when quite dry they will be ready for use. If the mixture is of suitable moisture, there is no difficulty in making them, and, as they are duly fluxed and do not crack during the smelting, they are better and much safer in use than charcoal.

For solid and trustworthy supports, you must have either willow or pine coal, as all others are liable to spark and crack; but any *pulverized* charcoal will answer for these moulded supports.

T. The folded fluxed paper cartridge which contains the ore being now put in the moulded fluxed support, place the solid handles of blast-pipes into the main blast-holes; the wind being thus securely stopped, blow in a full breath into the machine, to elevate the water into the upper cylindrical column, where it should keep its level if all is well; if it *does not*, see Chapter IV, on that subject. With the water thus *kept at the maximum height*, light the four wicks, and closely observe that they are neither too tight nor too loose, and that they are suitably trimmed, just in line with the blast-pipes. The oil chamber should be also *quite full of oil.* Allow the wicks to burn well up before commencing blast, or they will be slow in doing so when cooled by an overpowering blast.

U. Fix a piece of good solid charcoal in the four spring fingers of the suspension lever, as seen in Figure 21, page 172, and lower it over the assay, to within the fourth of an inch of the top of the assay paper, at such an angle as will not obstruct or divert the flames before the nozzle's blast, the objects being to cover, and thus prevent radiation and increase combustion, but not to actually receive the blow-pipe's flames, which must concentrate on the assay, and bottom or bed-coal. If you have no large piece of charcoal, you may suspend the cylindrical furnace to this spring lever, (as seen in Figure 28,) and supply it with a few pieces of the size of beans, and about two inches deep over the transverse fire-bars, which have been especially arranged for this purpose.

V. Now take out the blast-pipes and see that they are all clean and clear; if they are not, just wipe them with a rag, or free them with a needle that is *smaller* than the *holes*, and which has had its *temper destroyed* by *red heat*, in the fire. These *two things must be strictly observed*, so that you may not *enlarge* or *choke* the holes by extra size, or break the hard brittle needle therein, and stupidly *disable* the machine.

Replace these twin-pipes in position and sit down, if the ne is on a table; or, if no better place can be found, spread lanket on the ground, and lie thereon, with your head on dle for a pillow, so that you may take hold of the cork on em of the assay cup with the left hand, and be in a position w an occasional lungs-full of wind into the machine, and the progress of smelting. We will now, however, suppose t is either on a suitable rock, on the edge of a prospect- it, or on a table, and thus the smelting may be effected as vs:

ce the wick-lever at its inward limits of travel, so that the flames shall concentrate on the assay. At first, for some r three minutes, *blow very gently* into the machine, and see the flames play correctly on the sample; if not, move the ort by the cork on the stem, and the suitably swiveled hori- l spring levers, either towards or away from you, or up and n, by the same diagonal screw beneath the cork.

e assay must be occasionally turned around, but the flames not be continuous just at this time, which is the roasting oxidation period; so that you have time to consider your ements, and fix in thorough running order for reduction.

move the wick-lever outwards to its *terminus of travel*, so that four full yellow flames shall *concentrate on* and *cover* the assay, st the suspended coal or furnace should also be lowered as e down over it as the routes and free passage of the flames permit.

he currents of air from the nozzles should not travel exactly *ugh the centers* of the flames, as they are then more liable to *xtinguished under strong blast;* and therefore, if such should r, you can bend the intermediate wicks a little inwards, and end wicks outwards just sufficient to prevent it, without injury he flames.

ow blow full breath into the machine occasionally, and when ping to breathe, take notice if the flames begin to weak- so that you may renew it before they stop: it will be ferable for you (until you become familiar) to blow in a full ath, and then breathe twice or thrice between each full sup- of air to the machine.

Take particular notice when the greatest heat is produced, a that it concentrates immediately before and upon the assay sa ple. Now the smelting proper begins, and the flames must b not only continuous, but well directed, and of the greatest po sible heat. Turn the assay cup slowly about two rounds one wa and then two rounds back again the other way, to give all sid of the assay a fair chance, and to keep it at the same prop height in the center of heat. The lead buttons will by this tin have commenced to aggregate into one, which will now trav around the slag, and you must encourage this traveling aroun and through the scoriæ as much as possible, by *gradually i clining the stem and assay,* so long as you are satisfied that it wi not roll overboard, and be thus lost. When the smelting is wel performed, in from eight to fifteen minutes after these yello flames have been thus continuously blown, the *slag becomes sup ple,* and the white-hot button travels *freely through and aroun the slag,* whilst it partially encloses this central button, jus as the lid does the human eye. This desirable effect is a mar of success; and when produced it may be laid aside unti quite cold.

If the slag is thick and immovable, or much scattered, its condition can be bettered by collecting or stirring it with a small twig of wood, held in the right hand, whilst the flames are still playing thereon.

The following must be always secured: as, good oil and well-trimmed wicks; good supports, with the assay well centred in the heat, the blowing must be so studied that the greatest heat is produced; the covering of charcoal must be positioned correctly, for this is the most efficient cause for the successful treatment of such a large quantity.

The long furnace, with iron bars at the lower end, (as seen in the view, Figure 28,) will be found very serviceable, when you have no large pieces of willow or pine charcoal to suspend in the elastic fingers, for it may be simply attached to, and suspended by, the round handle of lever over assay; this furnace may be supplied to about two inches deep with several small pieces, the size of beans, and as this covering fire, when thus supported on the small fire-bars, can be correctly lowered to exact position, th for smelting and cupellation, it will be often found more nvenient, and always more practical, as well as economical.* The lead button or buttons, with the adhering slag, may be st parted and cleaned when wrapped in a strong fold of rag, d made ready for cupellation by being hammered flat, so that e metal may be more thoroughly cleaned and solidified into a be, as previously described for other assays.

X. Whilst the button is cooling down, the bone-ash cupel ay be placed in the hot cup, and the covering of charcoal, or e upper furnace, lowered over it, so that it will become dry, ot and ready, by the time the button is cleaned.

These cupels may be made in two ways; the first for immediate se, by squeezing moist bone-ash into the concavities at each end f the brass mould Number 21, and then further shaping and moothing them with the suitably convexed bed and top plates Numbers 20 and 22). The one end must be filled, compressed nd smoothed; and then, by inverting it on the table, or rock, without taking off the smoothing and shaping plate, the second end can be filled in the same manner; and then, after the two brass shaping-plates are removed by a suitable twist, the central double cup, that contains the bone-ash, (Number 23,) may be placed into the assaying bell cup, and dried for use. The second method of making cupels is by placing the cylindrical mould (Number 12) on the larger (Number 13) bed-plate, (as Number 14,) and, after filling it with compressed moistened bone-ash, to make a short ram (Number 15) form the upper end concavity, by causing it *to just enter therein*, (as Number 16;) and after placing a piece of wood upon it (to prevent its being injured), to force it down with a *hammer* or stone so as to make it sufficiently tight for its purpose; and then, after taking off the bottom by a twisting motion, invert the mould, and with the flat end of the ram

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*The heat and consequent smelting power may be much increased by a simultaneous central jet of either hydrogen or oxygen gas, made for the purpose, and supplied as highly inflammable tributaries to the regular currents of burning gases from the olive oil lamps of machine. By having a *nozzle for each gas*, they may also be separately made just when required, and ignited without danger of explosion, to produce their well known combined effects.

Or a vessel of alcohol may be warmed, beyond the assay, and its vapor then conveyed by a turned pipe and suitable nozzle into the center of the currents from blow-pipes. Air may be also passed through gasoline, when contained in a separate and *distant* vessel for absolute safety.

(Number 15) resting on the table, twist the cylindrical mo
(Number 12) gradually down to rest upon the table, when
naked cupel of bone-ash (as seen in Number 17) may be ge
removed with the fingers (as Number 18) to a safe plac
dry, for use when required. Such had better be used when
are fixed in comfortable quarters; but they are too fragile
traveling purposes.

Y. THE CUPELLATION OF BUTTON BY MACHINE may be perform
as follows: With the wicks as they were for smelting, and
covering of charcoal close down over the cupel, blow the fla
thereon until it becomes red hot; then place therein (wit
stopping) the clean and hammered button, which will alm
immediately settle into a molten semi-globular shape; as soo
it looks quite fluid and bright, having no slag or oxide incru
tion, draw the wick-lever almost close into the body of the
chine, so that the *two nearer flames* shall be *small and blue*, wh
the others are a mixture of yellow and blue.

Remember that *just sufficient heat* must be produced to k
the *button quite fluid* and the *cupel* in such condition that
litharge, or oxides of lead, etc., may enter therein without fro
on the surface, or clogging its pores; and also that *oxidati*
facilitated by excess of air, when accompanied by *sufficient*
These effects may be attained by paying proper attention to
position of button, which can be varied at pleasure by the
commodating holders, the stem screw, the covering of charco
and the transverse motion of spring levers from the yellow he
ing or reducing, to the blue oxidizing flames. This latter m
be modified, or better performed, by appropriate oscillat
twists of the cupel by the cork stem. The cupel should be occ
sionally turned during cupellation, so that different parts of
bone-ash shall be heated, to absorb more base oxides. You
here again notice what manner of blowing will reduce the siz
the button quickest, and will be enabled to produce either
minous fumes of white oxide before the *excessive blast*, or
peculiar *wave-like* oxidation from the surface of button into
bone-ash, when it is held *half within* and *half without* the fla

This machine is much more powerful for reduction than ox
tion, and if any difficulty should arise, the speed of oxidat
may be increased in the following manner: first, the *nearer*

last-pipe may be *slightly turned inward* so as to unsettle or change he focus of action and thereby admit sufficient oxygen at the ide; and secondly, you may use intermittent blast so as to get he button and cupel thoroughly hot, and then stop blowing for few seconds, that it may oxidize as in muffle, and repeat such ctions until finished.

You will have no difficulty in oxidizing the base metals off lowly, and a little practice will increase speed.*

Until you become perfectly familiar with the appearance of silver and gold buttons, you had better first cupel down to the size of a buck shot, on the one side of cupel; and after taking it off and thoroughly cleaning it with pliers and brush, to finish its cupellation on the clean side of the *red hot* cupel. In this way, the clean ash will, in a manner, dispense with the necessary intelligence for purification.

The pure button of silver should be frosty silver-white, and when slowly cooled, it will suddenly expose, one or more. warty protuberances.

When the cupel is quite cold, lay it on its edge, in a perfectly clean plate or saucer; release the button from the bone-ash by a careful twist with a pen-knife's point, and clean it by a sq[illegible]e of a clean pliers and brush, or by rubbing it on the plate with a piece of hard and smooth white paper, until it is sufficiently clean for valuation.

Z 1. TO ASCERTAIN THE VALUE OF THE BUTTON BY THE CALCULATING LEVER, OR THE DIVERGING STRIP TABLETS.—Balance, with weight A in the pan, the main lever's pointer to settle one-sixteenth of an inch above the bottom of the opening, and move the appropriate transverse lever's line to agree therewith; do this with the most conscientious care, as directed under the letters A, B, C, D, E, F, and then remove the weight A from the pan so gently that no motion will be communicated to it and the lever. Next place in the scoop one of the nearest plainly numbered weights—say No. 1—and drop the button, by laying the forceps gently down on the edge of the box, into the groove of

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*A 200-grain button of lead may be cupelled, after you are fully acquainted with the mode; so that you may smelt twice, thrice, or four times, and cupel the several buttons together: a crucible or scorifier button, or lead bullion, amalgam sponge, or granular and fine gold, may also be alloyed with lead, and thus cupelled and purified.

the long end of the lever, just over the figure, in the column
figures, that will pay for being worked by milling, smelting, e
and again see if the pointer is above or below the line on
transverse lever's line; if it then stands above, the assay is too
for its being worked profitably, and what you require is alre
known. If you desire its exact value, move the button outwa
by a *small piece of thread*, about a *half-inch long, inserted tr*
versely in the cloven end of a small sprig of wood, until the poi
stands exactly opposite, or the next less weight is required
balance for value. If, on the other hand, the silver button
fords more than the expenses required for working the ores,
may be carefully moved inwards by the thread, until you are
formed what its value is on the No. 1 column, or any other nu
bered weight and column (as seen on Number 1, Figure 31).

If it should pass *still further in* than the *highest figure* in
column, you may judge what larger numbered weight will
required to perfect the lever's balance, and very carefully sub
tute such weight for the No. 1 in the pan, and again move
globule to balance. It may be so large, and you so fortun
that even the largest plainly numbered weight will be insuffici
t[illegible]alance it, when one of the weights marked 3 X , etc., wo
be required; if so, balance the pointer with the suitably nu
bered weight, and read *ten times* as much as the figures op
site the button in the same numbered column, (3 in this ca
by adding a figure 0 to the right of the column (thus, 2,000 wo
become 20,000, etc.)*

In recent machines, the weight marked X 2, Figure 29,
not been considered necessary.

Z 2. To Ascertain the Money Value of Buttons, from
and 10 Grain Assays, for Gold or Silver, by the suitably Gr
uated Diverging Strips of the Patented "Explorers' Ta
Gauge Button Valuer."—Harkort, the celebrated Swedish che
ist and blow-pipist, was the first to measure the very small b
tons that were produced from blow-pipe examinations for g
and silver. He *drew* two straight *diverging lines* on *ivor*
paper; the one divided into fifty equal parts, and the other
loths' weight, as then calculated by *cubing the transverse line*
neath the diameter of button, when placed with a forceps u

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* Here the real weights equal the numbered differences over A.

agnifying glass, to exactly fill the intervening distance. He eaded the left-hand column 50, and the right-hand column 43.62 loths *in weight*, recording the loths down, at every fifth art, to 0.14.

Plattner, in a subsequent work on the blow-pipe, gives these cales, and suggests another, as more suitable for blow-pipe uttons, headed 50 on the left, and 122.5 on the right; also *marked ith loths* at every division, (instead of every fifth division of arkort's,) down to 0.0009. Both of these required great skill nd care in *correctly placing the button;* and, although they were, *heoretically*, excellent measures for weight, few men have preended to realize much benefit therefrom, in *practice;* whilst *either* of the two had the very practical advantage of *efficient jamming between side-straight edges*, nor recorded the *direct money alue at sight of gold or silver*, for blow-pipe or any other "assay ton," without further calculation.

In the patented "Explorers' *Tablet Gauge Valuer*," two *diverging and straight strips of metal*, being permanently secured on a bed, form *both guiding side fences*, as well as a *correct gauge of the diameters of buttons;* so that when a small globe of gold or silver, the product of the machine's assay, is dropped into the [illegible]r end of the gauge, it *naturally rolls down* to jam against *these sides*, the one of which is marked in dollars per ton for gold, and the other in dollars per ton for silver, and read at sight, without any calculation, which can be rendered into pounds and florins by simply dividing these dollars by 5. It may also be used for one grain silver assays, by multiplying the figure opposite the button by 10. It will be thus seen that this is a practical instrument, which can be used for approximate purposes by any one who can simply read plain cash figures, and that it is not a theoretical toy, for merely exercising the *judgment* for its true position *over lines*, as seen under inaccurate divergent lines of vision, and governed by the inadequate capabilities of the *hands and fingers.*

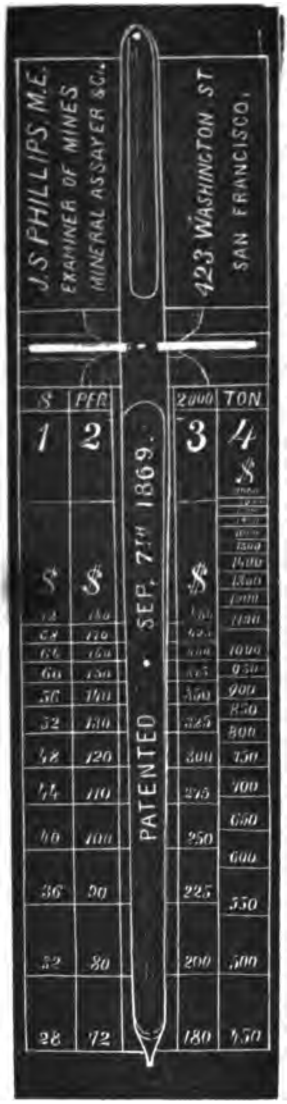
See illustration for manner of graduation, (Figure 31, No. 2.)

For alloys of gold and silver, see "Assaying of Bullion, or Parting of Gold from Silver and the Base Metals, by Fire and Acids," near the end of this chapter, under Heading 25.

If a button from a *ten grain* assay is found by parting to have gold, multiply the dollars upon the *tablet or lever's* table by 16 for dollars of gold per ton, as the tables agree with a sample of

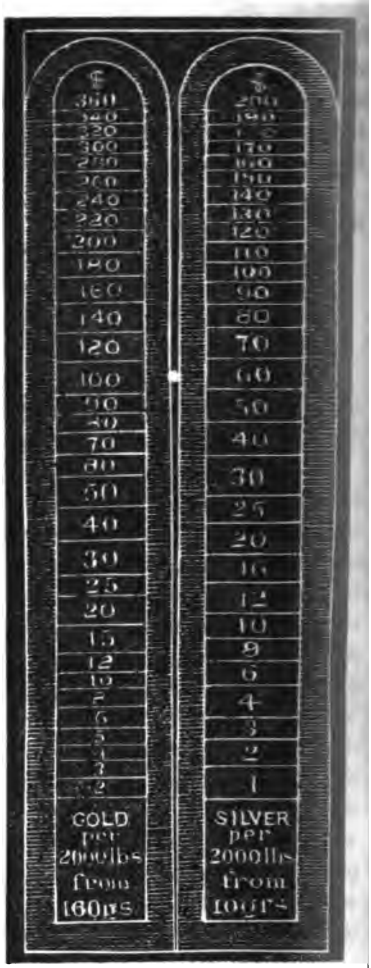
Figure 31.

Number 1.



Calculating balance for thousandths fine of bullion, percentage in base mineral assays, and for values of gold and silver buttons, in dollars ›n from 160 and 10 grain assays. nted with "Wee Pet" Assayer, th, 1869.

Number 2.



The Explorer's Tablet of the value of gold and silver globes, the resultants from samples of 160 grains for gold and from 10 grains for silver; as measured by these suitably graduated diverging strips of this "Explorer's Assay Button Valuer," which has been patented with the "Wee Pet" Assayer, Sept. 7th, 1869.

The Tablet is held at slight declivity, and the button is rolled down (one or more times, to obtain average), stopping as above at $110 if for gold, per ton of 2000 pounds, and $64, if for silver.

6 times as much, for gold; and, if 160 grains gold sample hould produce silver, divide it by 16. So, also, when a button [illegible] a 10-grain assay for silver *produces gold*, either at first or [illegible] parting by nitric acid, the figures which lie opposite the [illegible], when it is again balanced, must be multiplied by 16; and [illegible] by 16, as previously stated, if silver should be produced, [illegible] of gold, from 160 grains.

[illegible] THE ASSAYING OF GOLD BY MACHINE, IN ITS OWN INDEPENDENT WAY, AFTER WATER CONCENTRATION, BY FLUXED FUSION; READING THE DOLLARS OF GOLD PER TON, AT SIGHT; EITHER ON THE SAME SILVER TABLE UNDER CALCULATING LEVER, OR BY TABLET.

[illegible] this sample a suitable *quantity* must be taken for the machine "assay ton" for *gold*, so that the *calculating lever's table for silver* and the tablet gauge, may also value for this metal.

Fold a small business card along the middle, like note-paper, form a long paper pan, which pass through the bow of scoop of main lever of calculating balance, and cut slips from the upper edge of this paper card until it balances the pointer at the other end with the line on the cross lever, as the 10-grain weight marked. And when balanced, previous to weighing the sample for the silver assay, but with this difference, that the paper-pan being 10 grains must now remain in the pan. Take the round *brass bar weight* that lies in the middle of the weight-box, and gently place it down in the groove on the long end of the main lever, so that its outer end may be exactly over, or straight with, the *transverse line*, over which the $80 and $200 figures stand, and shovel your well-mixed and prepared sample into the paper scoop, until the pointer again stands opposite the line on the cross lever's point, when the card paper will contain 160 grains, the requisite quantity for the calculator, and sufficient for a gold assay.

Carefully concentrate this 160 grains, as directed in Chapter III, and after drying the heavy residue, and extracting the metallic iron, from pestle and mortar if such were used—by a magnet or magnetized pen-knife, if you have them—smelt, cupel, and balance for value, precisely as directed for silver assay by machine. Judge of its fineness and value by color, or part by acids, as directed towards the end of this chapter; then re-smelt with a very small amount of lead, and cupel into a button, for final weighing. In this operation, it will be sometimes very efficacious to place a small piece of charcoal almost over the button as it lies in the cupel, to increase the heat and brighten up the alloy for cupellation.

In assaying free gold from clean quartz, where very little or no sulphurets are present, 10 times 160 grains may be taken; (1600 grains,) and, in reading the calculator, divide by 10 for value, by taking off one figure from the right-hand side of those opposite the button, and headed by the same number of column as that on the weight.

17. ASSAYING BULLION BY BLOW-PIPE OR MACHINE FOR VALUE IN OUNCES OR DOLLARS PER TON, THOUSANDTHS FINE AND PERCENTAGE.

It is frequently necessary to obtain some knowledge of the grade of base and precious alloys of bullion during practical reductions, and for such hasty outside requirements nothing surpasses the blow-pipe or machine.

A. Base metal bullion generally contains sufficient lead for direct cupellation, and as dollars per ton is often required, all you need do is to take any suitable quantity and *calculate* for result, or use the S-weight of "Little Wonder," (3.771 grains.) for blow-pipe, or 10 grains for machine, and calculate, after cucupellation and parting, by either mode, in manners previously explained, for dollars per ton. If you wish to ascertain the *ounces*, from the *dollars value*, multiply the latter by 14.58 and divide by 18.85, or *dollars* from *ounces* by inverse proportion.

B. Precious metal or high-grade bullion is valued by thousandths or hundredths fine, and generally lacks sufficient lead for cupellation. Take any suitable weight of bullion for either of the methods of calculation described, or a quantity equal to the *self-culating red rider weight* of "Little Wonder," or B-weight of machine, as described for bullion and base metal assays, and after adding sufficient lead for effectual cupellation, and parting by nitric acid, to then value, by the rule of the method used, as described under its heading. It is well to remember that *any weight* of *rider shape* may be taken for bullion and base metal assays, in mode after "Little Wonder," and it will *re-balance* the resultant button just opposite the thousandths fine or percentage; it will be also often found more convenient to *file such a weight* equal your bullion, than to scrape the *bullion* to equal the eight; and as it will then represent just 1000, its simplicity reatly favors it for *amateurs'* purposes.

For cupellation by blow-pipe, see new method at page 209, nd the manner of cupellation by machine has been described t pages 317, 318, 319.*

Weigh the bullion for machine as described in Chapter IX, nder the heading "Assaying of Lead and Antimonial Lead Ores y the 'Wee Pet' Machine," and read its thousandths fine on its elf-calculating table by using the X 3 and X 4 weights in *direct* manner. See parting gold, silver, etc., under Heading 25.

18. ASSAYING OF GOLD SULPHURETS BY ROASTING, ACIDS, WATER, AND MACHINE OR BLOW-PIPE.

Roast 160 grains in an old cup, crucible, or iron ladle, in open fire, with half its weight of powdered charcoal, at a red heat, gently stirring nearly the whole time with an iron wire, for from a half to one hour, until no sulphurous fumes can be recognized when it is removed from the fire; then pulverize in the same vessel, by rubbing. Carefully transfer the whole contents to a clean cup, saucer, basin or dish; add thereto double its volume of pure hydro-chloric (muriatic) acid, which does not dissolve gold, and boil in the chimney, or open air, for an hour.

Add water, pulverize, and pass off all the light floculent matter, and the iron that is in the solution; smelt, and cupel the residue, and directly read the value in *gold* under lever, as if it were a 10-grain sample of *silver* ore, as a 10-grain silver and 160 gold assay are just the same in these calculated results. In this case, the roasting may be effectually performed by machine, either in the *transversely inserted* muffle-like crucible of clay or platinum (as shown by Figure 32), or the crucible may be placed in the burning charcoal of the cupola furnace from above, then heated by the oil flames, as may be required.

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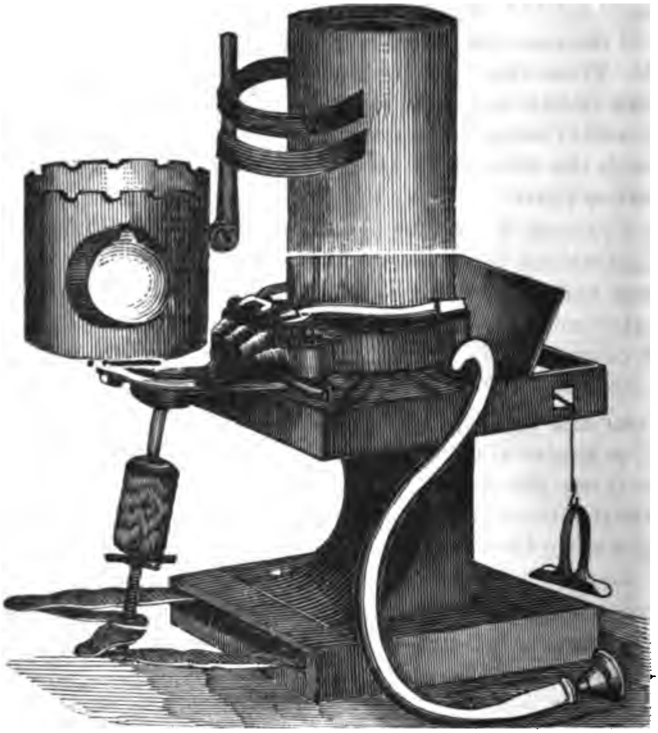
*In cupelling larger quantities by blow-pipe, I have found it efficiently convenient to take a *thin tube* or cylinder, as cut about three-eighths long, from a three-quarter inch brass pipe, and then to so ram it with bone-ash, that each end shall form a separate cupel.

This being dried may be placed in the enlarged space of the charcoal after smelting by any shaft and tunnel method, as described at page 208. These enclosing walls of charcoal will provide a burning fire that will keep the bone-ash and thin brass ring red hot during the whole time, and the cupellation can thus be more readily performed when large buttons are being treated.

Figure 32.



(Fixed for Roasting, Fusion *at any required degree*, and Ignition.)

19. ASSAYING 100 GRAINS OF SILVER ORE; BY ROASTING, ACID, COMMON SALT, AND MACHINE OR BLOW-PIPE.

It may be sometimes desirable to assay a larger quantity than 10 grains of ore, which you can do as follows, in a very correct manner, even when chloride of silver is present, which, in its unroasted state, is insoluble in acids.

Weigh 100 grains of the properly prepared sample, which roast for thirty minutes, in a cup or crucible, at red heat, with half its weight of pulverized charcoal or flour, (to decompose chloride for solubility in acids,) and stir it the whole time, with a long but small iron wire. After it becomes cold, first pulverize by rubbing, then transfer it to a porcelain cup, and add to this roast-d ore twice its volume of nitric acid, diluted by a thimbleful of distilled *rain* or *snow* water.

Boil the contents for one hour, and allow it a half-hour to get cold. Filter this liquor through blotting or filtering paper, into a clean bottle, and pour in about two table-spoonfuls of some pure water (because it contains no salt) above the residue, to wash through the remaining liquid, which might otherwise still retain adhering silver.

If you have no glass funnel, you can substitute it by inverting a small whisky bottle between your knees, and suddenly striking a large nail through its externally concaved bottom, to form a suitably small hole. The bottle should be first filled with sawdust or sand, so that the severed piece may not break other holes, and spoil it for filtering purposes.

Pour four table-spoonfuls of water into another bottle or cup, with a teaspoonful of common salt, and, after it is dissolved, pour it into the assay solution very slowly, drop by drop, taking notice if it renders it milky, or curdles white, by forming chloride of silver from a union of the chlorine of the soluble salt with any silver then present in the solution. If there is no silver in the solution, it will not become, in the slightest degree, milky, and the smelting and cupellation need not be performed; but, if it change ever so little, you may proceed by adding more salt water until the liquor ceases to be affected thereby. (If you give it all, *provided it is in solution*, although it is unnecessary, it will do no harm.)

Now by again filtering this liquor slowly through a *small* piece of blotting paper, the curds of chloride of silver will not pass through, but remain on the upper side of the filter, and when quite dry can be safely and snugly folded for smelting.

If you wish a machine button, dry the filter at the boiling heat of water, and after thus folding to enclose the chloride, place this ball of paper in the charcoal support of the assaying machine, and on it 10 grains (one balancing) of borax glass, and 40 grains (four balancings) of test lead, and then gently increase the blast to heat and cupel, as previously described.

Of course, this button will balance over a figure that is ten times too high for the calculating lever's table, by the ordinary weights for the 10 grain assay, so that you must either strike off a figure from the right-hand side, or use the weights X 3, X 4, and then read the figures as they are on the calculator's columns.

20. ASSAYING OF SILVER BY AMMONIA, NITRIC ACID, AND SALT; THEN SMELTING AND CUPELLING TO BUTTON, BY BLOW-PIPE OR MACHINE, WITHOUT ROASTING.

Where you have ammonia, nitric acid and common salt, but no facility for roasting, take 100 grains of silver ore, that you suspect may contain some silver in chloride form, which is insoluble in acids, but completely soluble in ammonia. First, dissolve what you can, by boiling in a bowl for an hour, in about thrice its volume of watered nitric acid; allow it to get quite cold; then, after adding about a wineglassful of distilled, or rain, or snow water, filter the liquid through into another bowl. Next, pass a second wineglass of water through the solid residue on the filter, to dilute and wash the *last trace of nitrate* of silver, etc., etc., into that already passed through. Precipitate this solution with salt, as in the last example. Next lift this funnel off, with the undissolved ore, and spread the filter in the bottom of another clean cup, which just cover with ammonia, and warm it for a quarter of an hour over a coffee-pot half filled with boiling water. Lastly filter this solution into another clean cup, and well wash out the relics of solution from these gangue residues and spongy filters, with pure water, so as to obtain the whole of the silver.

Now precipitate or re-unite the silver from last solution, as a chloride, by the *slow* addition of nitric acid; and, after carefully pouring off this liquid and adding a wineglassful of pure water, you may strain both solutions on separate filters, and finish into button by machine, as before.

As ammonia precipitates many other minerals from nitric acid solutions, they should be treated separately *to the end*, as described. Any lead or mercury that might be simultaneously deposited, would not interfere with correct results, by smelting and cupellation.

Thus, the precipitated residue from this large quantity of 100 grains (or even more) may be correctly smelted by blow-pipe or machine.

1. HUMID ASSAY OF ALL KINDS OF SILVER ORES.

Weigh 100 grains, and then, first, manipulate under the directions of either A or B, until you have precipitated all the silver, as a pure chloride.

A. Treat the sample by roasting with charcoal, dissolving in nitric acid, and precipitating with common salt, as explained under heading 20, and then, to *insure purity*, you should, in this *humid* case, first dissolve the thus precipitated chloride of silver by ammonia, (so as to free it from lead and mercury,) then filter and re-deposit it by the nitric acid, and filter for valuation by drying and weighing, as explained below.

B. Dissolve the sample *without roasting*, as under heading 20, and use the above precaution about lead and mercury by dissolving the chloride of silver from the acid, in ammonia; when, after re-uniting the two ammoniacal solutions, you must precipitate by excess of acid, then well wash, dry and calculate as directed in the following paragraphs.

Having a superior balance and set of weights, you may remove the filter to a clean porcelain bowl, and dry it thoroughly by placing it, as a lid, over a sauce-pan, kettle, or coffee-pot, half filled with boiling water, for at least one hour, or until it ceases to lose weight; then hold it in forceps, and burn the paper thoroughly by the application of a match, so that the chloride residue may fall into a clean saucer. Sweep this into the scale-pan, or balanced weighing-cup, and record its weight. The weight of the well-burned, extremely light residue of paper, may be known by burning another similarly sized piece, when, by weighing its residue, the proper allowance may be made.

Another, and perhaps more satisfactory mode, will be to dry perfectly, at boiling heat, two exactly similar filters, and carefully balance them in the scale-pans, by cutting chips from one or the other with scissors.

Filter the solution through the one, and *dry both as before;* then the *difference* of their weight will be equal to the quantity of chloride of silver that is present. Or you can first *dry one filter*, and exactly balance it, if you are going to finish the assay right through; and after filtering thereon, when the precipitate has been thoroughly dried, to balance the both by additional weights, which will at once give the actual weight of the chloride of silver.

It is self-evident that where there is the least chance for lead, mercury or salt being present in any form—nearly always so in tailings, but seldom in ore—the preliminary roasting and final smelting and cupelling operations are to be preferred; for the former volatilizes the otherwise dangerous mercury, whilst the latter passes off lead and all spurious matter, by cupellation, to give you the much more satisfactory and tangible silver button.

The chloride thus obtained contains 75.3 per cent. of silver; so that, by referring back for your corresponding assay unit to the quantity taken for assay, you can readily calculate as before, after knowing the actual weight, in such units, of silver obtained. Thus, if 100 of chloride gives 75.3 of silver, how much will *your weight* (say 1.2) of chloride yield of silver?

Or 75.3 multiplied by 1.2=90.36, which, divided by 100, will give .9036 of assay unit.

Or 75.3 x 1.2=90.36, and, by moving two points to the left, is divided by 100; thus 90.36 becomes .9036.

Or move the multiplier two to the left; thus, instead of 75.3, say .753 x 1.2=.9036, as before.

Or weight 1.2 x 3, and divided by 4=.9, will be sufficiently near for most purposes, as it varies in this case but thirty-six ten-thousandths of $37.71, or only just thirteen cents per 2000 pounds ton.

22. ASSAYING OF SILVER BY THE USE OF COMMON SALT, CALLED "VOLUMETRIC."

This method was first devised by Guy Lussac, and, although it is very suitable for the purposes of experts, with laboratory facilities, who have many assays to work through every day, most of which may be bullion, it is certainly not so useful for the occasional, more diversified practical purposes of the miner, millman or smelter; and therefore it has been seldom used in preference to other methods.

In common with all the peculiarly acid modes, where salt is the precipitant, the lode or its mineral should contain neither *salt* nor *mercury*, (so frequent in milling and not always absent from vein); for the former, *even after roasting*, would precipitate the nitrate of silver to an insoluble chloride, so that the filtered solution would be robbed of this much by its lying on the upper side of filter; whilst the latter, unless the sample had been roasted, by rendering the filtered solution milky, from the nitrate of mercury being thus changed to chloride, would deceive the best judge, by creating a similar appearance, as well as using a larger volume of the test solution than belonged to silver.

It may, however, be used on ores, free from salt, after *efficient roasting* with charcoal powder, by dissolving and filtering to a clear solution, as directed under No. 19; but, instead of precipitating and weighing as described under No. 21, for the simple humid assay of silver, it is placed in a clear glass vessel, as a Florence flask, and the quantity of silver is ascertained by visual notice of the milkiness produced by certain volumes of a previously regulated salt solution. This clear solution, of silver with nitric acid, is then changed to a chloride by the addition of a highly diluted and correct standard solution of common salt, which renders the liquid more or less milky, and slowly pricipitates chloride of silver to the bottom of the vessel: when more salt solution may be then added to test the upper and clear solution, until the *exact time has arrived* when no milkiness is produced thereby. The measured volume of solution used corresponds with, and informs you of, the quantity of silver present in the sample by any *"assay ton" quantity* you may desire, as described for other methods.

For metallurgical works and mints, where large quantities of silver have to be otherwise treated in the wet way, it is frequently advisable to assay by this means, where it will be better to prepare the solution of salt in such a manner and of such strength that every 100 grains or volumes of the solution shall precipitate one grain of pure silver; and, to prepare such a solution, it will be necessary to add to every 99.4573 parts, by weight, of pure water, 0.5427 parts of pure salt, and to check and perfect for accuracy by subsequent trial on pure silver, with the graduated tube for this method of assay. This parallel and cylindrical glass tube, about fourteen inches long and one-fourth of an inch internal diameter, is graduated, for about nine inches in length, into one hundred parts, for reading equal volumes, the termini of graduations stopping somewhat short of each end. To facilitate its being filled and emptied as required, the bottom is somewhat contracted to a dropping point, so that, by applying the thumb to the top end, the liquid may be conveniently regulated, retarded, or stopped, by necessary admission or stoppage of the air, just when required during the test for quantity of silver in solution. Each mark will, of course, then represent one-hundredth of a grain of silver precipitated. Stronger or weaker solutions may be made, to suit any desired " assay ton," or for *hastening the work* during the first part, in assaying rich bullion. These solutions will require frequent corrections for strength, as well as for the temperature, and consequent change of bulk; and as I do not deem it sufficiently important for the reader's purpose to use some sixty pages for its full explanation, tables, etc., I must refer the very few who will require more information on the subject to John Mitchell's work on Assaying, where he has translated the whole mode of operations, etc., from the French description by the inventor of the process.

For occasional purposes, both for tuition and use, I have found it more convenient to nearly approach this solution, and to calculate for value as follows: Weigh out the last named ratios of filtered water and common commercial salt, and add a slight excess of salt, (or, in fact, any other ratio within practical limits;) then dissolve one grain of pure silver in nitric acid, and very carefully ascertain how many units of the one hundred parts of the graduated tube is required of the solution, to precipitate the one grain of silver; which, for illustration, we will suppose to be 98.

This may be then used as a base for calculation; thus, if 98 volumes precipitate one grain of silver, how much will the number of units required for your assay solution precipitate?—and you obtain the answer in grains; which will lead to any other answer required, by further calculation in the ordinary way for ounces or dollars per ton.

Here you may also simplify the mode, and come to direct answer, by taking any other silver button from assay of known *ton value;* dissolve it in nitric acid, and precipitate as you did the one grain above. Thus, supposing the dissolved button obtained from any assay ton represented $75 per ton, which required say 65 volumes of solution of salt for precipitation; it would again be, as 65 volumes are to $75, so are the volumes or units required for present assay, to its dollars per ton.

Or, as in the self-calculating systems, you may, by much patience and perseverance, so strengthen or dilute your salt solution, that each *unit*, being equivalent to "*assay pound*," may represent $1 in value for a suitable "*assay ton*," as fully explained in the self-calculating arrangements in the fourth part of this chapter. Or, you may only approach this *last unit quantity*, and calculate as just stated above.

The miner, miller and smelter may make good use of this, in a novel manner, for daily testings of what rock will exceed the cost of reduction; as if it required say $40 ore to pay profit, he may keep a suitable measure for the test solution, and cast only that quantity in the nitrate of silver solution first, and then add more to know if any profit remained.

23. ASSAYING OF GOLD BY "AQUA REGIA," ETC.

Gold can be assayed in the wet way, by dissolving say one part of the pulverized sample, placed in a glass flask, bowl, or cup, in two parts of what has been called "aqua regia," which is a varying mixture of from two to four parts of hydro-chloric (muriatic) acid with one part of nitric acid; the former being varied, for the best solubility of the associated base materials; the sample should remain for about two hours in cold solution, but one hour will suffice if it is kept gently boiling. This gold solution must be diluted with its bulk of water, then filtered through the regular filtering paper, (or common blotting paper, first soaked in clean water, will answer in its absence,) and evaporated over a lamp to perfect dryness, as described under the twenty-fifth heading, on "Parting," etc. Water must be now added to this dried residue, for the purpose of re-dissolving the chloride of gold that has been thus formed (by the chlorine from the hydro-chloric acid), and which is completely soluble in water. Lastly, boil this liquor with either oxalic acid or sulphate of iron in saturated solution, until all the gold is precipitated as a brown powder, which can then be well washed, dried and weighed, in the manner described under the twenty-fifth heading, on "Parting Gold from Silver," and calculated as under the third heading, at pages 270 and 271.

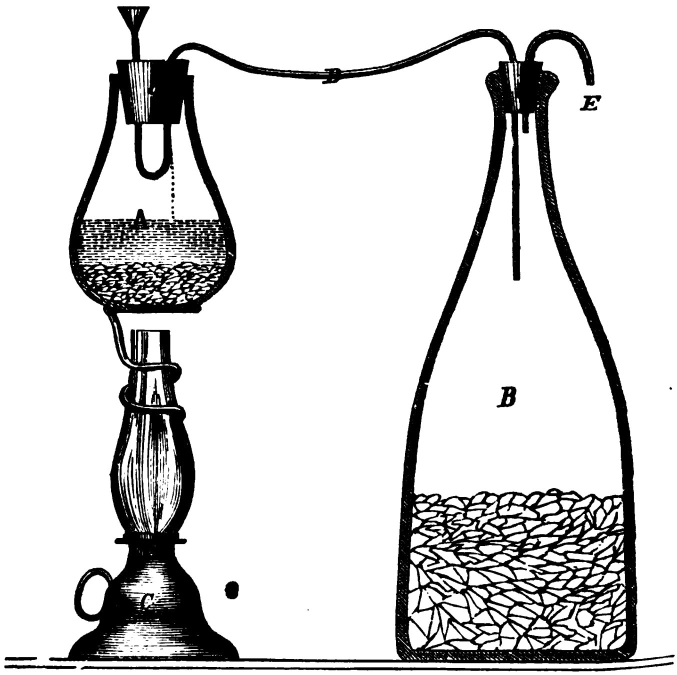
There are many precipitants of gold, but these will be best for your purpose. Oxalic acid may be made, when required, by

dissolving one part of sugar in six parts of nitric acid, boiling solution until the reddish fumes cease, and taking out the crys ***of oxalic acid when the liquor is cold.***

24. ASSAYING OF GOLD BY CHLORINE GAS.

A. Auriferous quartz and sulphuret of iron may be assaye and experimented on for ascertaining the percentage that can obtained from the ore on the large scale, by being dissolved chlorine water, chloridized by passing chlorine gas therein, an

Figure 33.



precipitated by sulphate of iron, in miniature apparatus (sold by those who supply assayers' materials), and which in action exactly resembles that of Plattner's process for the manipulation of roasted sulphurets on the large scale, which will be fully explained in the second volume of this book.

B. *For itinerant purposes, I would suggest the following extemporized means of assay and experiment, which can be perform* *with much greater ease and facility, and is even more correct and exacting.*

Take a large-mouthed pickle jar, as that shown by A, Figure 33, and a large demijohn, small-necked glass or stone bottle, as B, or other suitable vessel, (that will hold sufficient for the quantity on which you would wish to assay or experiment,) and the common naptha lamp, C, to warm the solvent.

A cork must be shaped to fit the large-mouthed pickle jar, and two india-rubber tubes obtained, the one about two feet six inches, and the other six inches long, and from one-fourth to three-eighths of an inch internal diameter, to feed the acid and form the connection as shown, so as to convey the chlorine gas, generated in A, to B.

Now, you should bore two smooth round holes in A's cover, and also two in the cork of B, just sufficiently large to make a gas-tight joint by mere compression on the rubber tubes.

To afford safety, and at the same time obtain the necessary pressure for urging the gas forward from A to B, as well as for providing a kind of "stink trap" to prevent the otherwise direct ascent of the gas, the rubber tube should be looped in the manner shown under the cork of A; and on the right or ascending side, at about two inches above the bottom of the loop, and say one inch under the wood cover, a hole, one-fourth of an inch wide and a half-inch long, must be cut; to allow the acid to pass in, as shown by the drops from the first or short end, and at the same time to give free passage for the gas from A into B, through the long end; thus all backward passage is prevented, without the use of glass fixings.

The other end of this pipe, D, may descend into B, about five inches; whilst the short tube, E, merely starts just under the cork, for the free exit of the lighter air as the heavy gas enters over the ore.

The apparatus being made as above, take twenty pounds of pulverized quartz, or sulphurets of iron; the latter must be well roasted and stirred at a red heat, with about a teacupful of finely pulverized charcoal, or common flour, for about two hours, in a wrought-iron frying-pan, and then allowed to become quite cold. This must be placed in the large demijohn, B, and gradually moistened with water throughout, by frequent small additions and shakings, until it becomes just the consistency of *masons'* *mortar for trowelling*, when you may force in the cork, *b*, to sto the mouth of the demijohn. Now place two ounces of finel pulverized *peroxide* of manganese in the jar, A, which securel stop with the cork, *a;* and mix eight ounces of hydro-chlori (muriatic) acid with four ounces of clear water, and pour this into the vessel, A, four ounces at a time, at intervals of about thirty minutes. The vessel A should be thrice the size of the mixture described, to afford sufficient room for ebullition. The chlorine gas thus formed, over a gentle heat from the lamp, C, is pure, and can be passed over through the rubber tube, on to the ore, and, being much heavier than the air, will lay down thereon, saturate its water, and dissolve the gold. Before *re-supplying the acid*, the large bottle, B, must be well shaken each time, which can be done after removing the cork, *b*, and substituting a separate one for this especial purpose.*

It can be done, however, without this, by stopping the rubber tubes, either by pressing them with the thumb and finger, or by a cloven-ended small branch of a tree, similar to a clothes-pin, or tying them with a cord, during the time required for shaking.

C. Another, still more convenient, and very easily applied method, is shown by the following illustration:

The bottle, A, is put into a sauce-pan full of cold water, and after being placed on a stove, or over any gentle fire, this bottle is first supplied with *all* of the dilute hydro-chloric acid and peroxide of manganese, as given in the last example, under heading B; then cork by *a*, which has now but one hole, to receive a half-inch rubber exhaling tube, that may not be more than about eighteen inches long, to carry the gas into the *open-mouthed demijohn* or jar: as the water gradually warms, the heavy chlorine gas is formed and forced through to fall down on the moistened ore, until the bottle becomes nearly filled therewith, which may be seen by its yellow color. The rubber tube may be now stopped for a moment, and the *whole gas-forming and supplying part removed out-doors*, or the tube passed down into another small-necked bottle for a few minutes; whilst the demijohn that conains the chlorine and moist ore is closely secured by cork *b*, and iolently shaken for some minutes, to more thoroughly chloridize he water for dissolving the gold; the demijohn is again placed n position and supplied, as before, with more gas, for another epetition of this shaking process, when it may be allowed to emain thus securely corked until next day.

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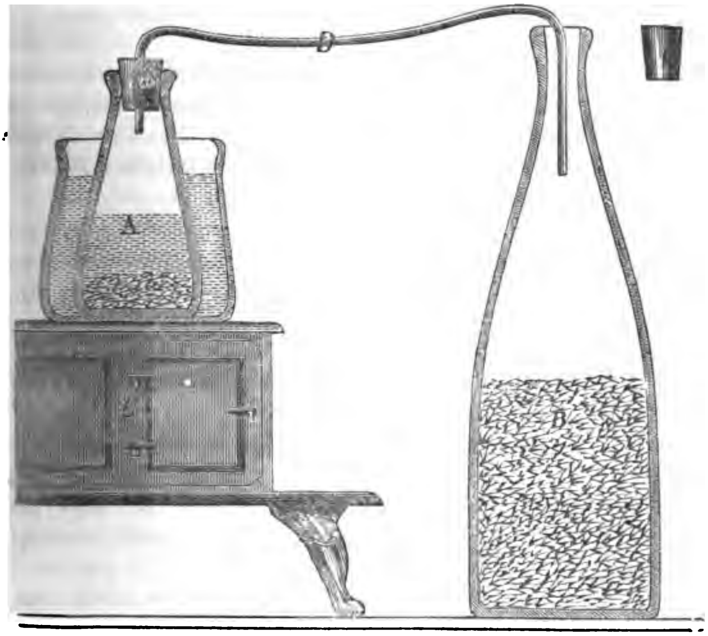
*This is a better and easier way for obtaining the chlorine gas, for assaying purposes, than the mode practiced on the large scale, where about eight parts of sulphuric acid act on a mixture of four parts of salt (chloride of sodium), five parts of water, and three parts peroxide of manganese.

Figure 34.



In the morning, pour in about one quart of water, and shake, as before, to absorb any remaining chlorine gas into solution, and loosen the whole mass of pulp; allow it to stand for an hour; then nearly fill the vessel with *warm water*, and, after it has had time to settle, carefully pour the liquid off into a clean earthenware or glass bottle (filtering it is much better, if you have the facilities); then, after pouring in a second quantity of about two quarts of warm water, to extract what still adheres to the residue of sample, the gold may be precipitated from the clear liquid by solution of sulphate of iron or oxalic acid, (made as described under heading 23,) in the following manner:

About twenty drops of hydro-chloric acid should now b added to the clear liquor with some dissolved sulphate of iron o oxalic acid; and it must be occasionally stirred with a glass ro (or a small inverted glass bottle, test tube, or slender piece o wood,) until all the gold has been precipitated.

This liquor must be filtered, the filter dried in a basin, a 212°, over a sauce-pan of boiling water, then flamed and burn to powder in this basin, and the gold separated by water-wa ing and subsequent drying, as previously described at pages and 294, under Heading 12 of this chapter.

The filtering may be dispensed with, if you lack such conve ience, or knowledge, by pouring the liquor carefully out, clea ing and drying the gold after the manner under Heading 12, a weighing it for value by the mode described under the "Partin of Gold from Silver," under the twenty-fifth heading of th chapter.

Or the gold can be separated from dirt, etc., by cupella with lead, if you have a furnace or *machine*, and in low gra cases, by blow-pipe.

To calculate the value per ton for a twenty pounds samp multiply this weight of gold thus obtained, by 100, for what 2000 pounds ton of such will produce.

For any other quantity, see the third and fourth headings this chapter.

Chlorine gas is not only disagreeably pungent, but very po sonous when inhaled; so that it must not be allowed to escap into the room.

25. ASSAYING OF BULLION AND PARTING OF GOLD FROM SILVER AND BAS METALS.

Theoretically speaking, you may take any even round numb to represent an exact thousand, as 1000 grains, or 100 grain (1000 tenths of a grain,) or 10 grains (1000 one-hundredths o grain), or 1 grain (1000 thousandths of a grain), and cupel wit sufficient lead to purify for *direct* answer, in thousandths fin of silver or gold; but for actual practice I have much prefer taking a sample only *somewhat near to any nominal thousand* a then *calculate results* for fineness, as directed at page 324, und Heading 17.

The manner of taking an average sample must naturally vary with the means at hand and the purpose for which it is intended. The miller should prefer to average high-grade bullion, when pouring the hot molten metal into bricks, by simultaneously dropping *very little* into a conveniently placed trough of water, from the first, middle, and last of his pot; so as to produce what are termed granulations for assay: the smelter of base bullion must be satisfied by chipping small pieces from the corners of say every tenth brick, and melting these into a general brick for assay; or by dipping from every direct discharge of metal from the furnace and saving these as water granulations in manner of the miller: the city assayer will re-melt and granulate, or drill a hole through the center, or run chances on numerous chips.

In the separation of gold from silver and the base metals, the following *hints should be kept in mind:*

1. The alloy of metals should not contain more than one-fourth its weight of gold, and if it does, (*which may be known by not being blackened by the nitric acid,*) sufficient silver must be smelted into the alloy, before the acid will follow the minute ramifications of silver, or other metals, to thoroughly dissolve them out and leave nothing but pure gold.

2. The nitric must be free from hydro-chloric acid, and have about a certain specific gravity, of 1.16 for large operations, by dilution with a proper quantity of water.*

3. The button should be flattened very thin, and boiled in the acid for from five to twenty minutes, and at least until all action ceases.

4. The residual brown spongy gold must be well washed, in either distilled, snow, rain, or, at worst, comparatively pure water, which must be particularly free from salt, that would increase the weight of the supposed gold, by depositing a coating of chloride of silver on its surface.

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* For the ordinary purposes of assaying, such as parting the resulting buttons, it will be quite unnecessary to observe this extreme nicety in the strength of the acid; for it will be seen that if a little too much water should be first used, it will quickly evaporate, so that this exact strength is merely nominal, and can be retained but for a second of time, as continued evaporation will soon pass *all* off, and rectify the acid. Therefore, about one part of water to four parts of the acid will suffice for such occasional purposes.

5. It should be warmed to red heat, until the brown metal shows a golden color, for more positive proof of its purity, and to free it from other substances which might have adhered thereto.

To ascertain thousandths fine for silver or gold, from carefully averaged samples of bullion, the base metals' thousandths are first oxidized away in the air and cupel, as in the smaller previous examples, which leaves the pure alloy of silver and gold.

The total weight of this refined button is first ascertained; the globule is then hammered or rolled very thin, and coiled into a more compact cylindrical shape; it is next placed into the bulb of a glass parting flask, which has the size and shape of a hen's egg, but prolonged by a half-inch tube from its smaller end for about eight inches, which serves for partially condensing the fumes from the acid and holding sufficient water to cleanse the parted gold and convey it to a small crucible, for being warmed to redness in the muffle of the furnace, which must be kept sufficiently hot for this purpose.

In mints, and the large bullion establishments of cities, several of these flasks are used together, and, after the rolled and coiled samples are placed in these vessels, the egg-shaped bulbs are half-filled with acid of 1.16 specific gravity; they are then placed in a suitable rack, at somewhat reclined positions, over as many gas-burners, to be gently boiled for some twenty minutes, or until all action ceases, so as to insure complete solution of the silver.

The flask must be now filled with *pure* water, then carefully decanted, and re-filled. Now, with the left hand, place the smallest sized French crucible over the mouth of the flask, and with the right hand gently invert the latter, so that its water may quietly pass away, while the gold drops into and remains at the bottom of the crucible, care being taken that all of the gold has been washed down, and if not the washing must be repeated. A little practice will be necessary to perform this with ease and certainty.

Being sure that all the gold has descended, you may now remove the flask, and, after pouring the water away from the gold, place the crucible first in the mouth of the muffle, for slow evaporation of its moisture, and thence into the interior, so that the may be increased to redness, for purification, etc.

It may be then removed, and, after it becomes quite cold, weighed as thousandths fine of gold, and this weight being deducted from the total, the difference will be the thousandths of silver.

I have used, when away from gas, the cabinet described under the ninth heading of this chapter, where the bottom front row of pigeon-holes were marked from A 1 to 10, for weighed assay; the second front row, marked B 1 to 10, received the resultant crude *button*, from smelting; the third front row, marked C 1 to 10, received the *cupelled* button; and the top row of the cabinet, marked D, received the *deposit* of gold, after it had been parted, in such flasks, that reclined against their respective numbers, over as many small lamps, which had been supplied with sufficient alcohol to burn the proper maximum time.

A common household naptha lamp will also be very useful for such purposes, when a small wire is entwined round the upper part of its glass chimney and terminated by a ring to support the dish; as C, under vessel A, Figure 33.

For quartz assays, and other isolated, occasional requirements of miners and metallurgists, the following will be more available and equally convenient, and, for such small quantities, much more exact, than the method described. Take, instead of this flask, a small porcelain dish, a thin teacup, or other similar *open* vessel, that will stand the action of acid over the necessary heat, and boil until all the silver is dissolved. This may be done over a sufficiently heated *clean stone*, a hot stove-top, or, still better, on the ring of wire over the lamp, as described; these being clean and smokeless, are superlatively convenient for such and similar purposes, whilst the heat can be by the latter suitably adjusted and equally sustained to suit your various requirements, by the wick-elevating side screw, as seen in front of lamp C, Figure 33.

This being accomplished, the acid may be poured away, and the vessel carefully filled with clean water and emptied twice or thrice, when the brown deposit of gold may be boiled in the half-filled bowl for just a few minutes, to remove any foreign adhesive substances; and then, after this water has been very carefully poured away, the dish and gold must be warmed so hot as possible, until you are satisfied, by its appearance through a magnifying glass, that nothing but gold remains. It will not attain general gold-like lustre at this temperature—only a partial but satisfactory color; which will, when bruised by a clean pestle, expose the bright yellow gold.

With the glass in the left hand, and a sharp-pointed pen-knife in the right hand, you may now loosen these sponges of gold, from the dish or cup, being careful that if any particle thereof sticks to the knife or forceps, it must be returned by a gentle tap on the edge of the vessel.

Commercial assays will demand still greater accuracy, and you should transfer these sponges of gold to a piece of platinum, gold or silver foil, and subject them to red heat, for just a few seconds, over an alcohol lamp, before weighing.

When these become *quite cold*, they may be easily weighed to the most exact degree of nicety that it is possible for your balance to realize, in the following manner:

Cut two similar pieces of common blotting paper, about one and a quarter inch long by one inch wide, and after folding them the *long way*, like a sheet of note paper, trim off the corners with scissors, so that they may exactly balance on your scales. This soft and compliant bulbous paper is much more suitable for such purposes than the more elastic, uncertain motioned and slippery, glazed note-paper.

Now, these being correctly balanced and suitably folded, you can remove the right-hand paper from the pan, to a clean dry spot, intervening yourself and scales, and, by taking the vessel that contains the gold in the left hand, you can so incline it that assisted with gentle taps of the pen-knife or forceps, every particle of gold may be made to fall upon the balanced paper, whilst the nearer half will form a vertical and most effectual stop-fence, and convenient handle for replacing it in the scale-pan, in ascertaining the weight of gold.

26. PARTING, BY EXTRACTION OF THE SILVER FROM A FLUID ALLOY OF GOLD AND SILVER, BY CHLORINE GAS.

The affinity of silver for chlorine is much increased by high temperature, whilst gold loses its affinity, and is therefore secure under such conditions.

These properties have been long known, and acted on in many modified ways for preparatory roasting and simultaneous chloridation of silver ores, to render them less refractory, for the various subsequent methods, for manipulation by pan amalgamation, smelting, or purely chemical treatment.

Plattner's process for extracting gold from previously roasted sulphuret of iron depends on the fact that cold chlorine water has such a strong affinity for gold that it can be readily dissolved therein, and again precipitated at pleasure, by sulphate of iron, etc., etc.

Mr. Miller, of Australia, the Assayer of the Sydney Mint, knowing of this indifference of hot or molten gold for chlorine, has recently experimented thereon at that establishment with apparent success, for refinage of their gold for coinage purposes. As it is irrelevant to your requirements, I mention it more as an interesting and novel application in large metallurgical works, than for profitable application in your business.

I see, from the inventor's lengthy description of the mode of operation, published in the *Chemical News*, that it is accomplished as follows:

One or more (of 17 or 18 sized) French crucibles are duly prepared with borax, and laid in the cold furnace, to be slowly and carefully heated to dull redness, when from 700 to 800 ounces of the auriferous alloy (cast in such shape that two ingots shall suit the crucibles) are placed in each one, and then quickly melted; from two to three ounces of fluid borax is now poured from another hot crucible thereon.

During the last ten minutes of this melting, a small fire-resisting clay tube, that forms the nozzle or fire-end of the chlorine-supplying pipe, has been slowly heated, so that it may not split when introduced into the melted gold. This pipe is carefully lowered to the bottom of the crucible, which must be now covered, and at the same time supplied with chlorine gas, to prevent the gold from rising and settling in the tube.

Being kept in this position by a few small weights, it is continuously supplied, by suitable pressure, with the gas, which quietly bubbles up through the molten alloy, without projecting any globules of metal from the pot.

Variously colored fumes arise during the process, which ind cate the presence and exit of the different oxides or chlorides the base metals; and when these have all passed, and all of th silver has been chloridized, the chlorine gas shows its characte istic yellow, and deposits this color on the stem of a white cla tobacco-pipe, when inserted through a hole in the crucible-lid plug being removed for that purpose; the operation (which re quires about one hour and a half) is now suspended, the crucib removed from the fire, and the liquid chloride of silver poure into suitable dry moulds. After its solidification, the red-ho gold is extracted, by inversion of the crucible, and thrown into concentrated boiling solution of common salt, which dissolve the adhering chloride of silver. It is said that all these opera tions can be readily performed, and about 2000 ounces refined i five hours, with three common melting furnaces, and that th thousandths and quantity of gold then retained will equal tha obtained from any other methods.

27. PARTING OF GOLD, SILVER, AND BASE METALS, WHEN AMALGAMATE WITH MERCURY.

The dry amalgam, as received from the strainer, or buckskin, when in considerable quantity, is first freed from the mercury by being retorted over a fire; the mercury is recovered by condensation, whilst the goldand silver will remain with the base metals, as metallic sponges; which may be fused in a crucible with borax, and cupelled in sufficiently large quantities of bone-ash, with a suitable amount of lead for proper purification, as described for cupellation on the small scale. The base metals can be also oxidized away by adding sufficient nitre to the borax, during fusion in crucible, so that the alloy of gold and silver may be then directly poured into moulds.

The silver and gold may be now assayed for thousandths fine of each, by either drilling a hole through the brick, or chipping off a sufficient quantity from the corners—say 10 or 100 grains—for separation by acid, etc., as under Heading 25.

Small lumps of well flattened amalgam may be wrapped in strong folds of paper or rag, with half their weight of borax, then gradually heated and fused in a somewhat capacious crucible with sufficient lead, and cupelled; or, being first correctly fused with borax and nitre, after the base minerals are thus oxilized, they may be more directly parted by nitric acid, without cupellation, as before; for thousandths fine and value.

28. REFINING OF GOLD AND SILVER FROM ALL SOURCES.

The refinement and separation of gold and silver, although a strictly metallurgical operation, is not always accomplished in the most direct chemical manner, but is often varied to suit local circumstances; and such reagents are used for dissolving and precipitating the silver as will best answer the two purposes of obtaining the silver and the resulting profits from the sale of the more suitable and simultaneous productions.

These commercial modes need not be exposed here, as the miner will not require them.

The most effective method for refining gold and silver is that so graphically described in the Bible; the base minerals were then oxidized, as they now are, by cupellation on a porous support, at suitable temperature before blast; the only difference being in the superior mechanical arrangements of modern times.

As the cupellation of large quantities of base bullion, for its silver and gold, must be illustrated and described in Volume II, on Mining and Metallurgy, we will now but consider the more simple and ready methods for the melting and cupellation of the smaller quantities as generally required by miners, after the more ordinary milling operations, rather than those from much more extensive commercial reductions.

These small amounts of gold or silver, when either separated or alloyed with each other, and with the base metals, may be treated in the following manner.

A. A crucible of good sound clay, or plumbago and clay composition, is selected, of suitable capacity for conveniently holding the required quantity of alloy; and placed in the furnace, in such a position that it can be enclosed with a sufficient amount of charcoal or coke, to produce the intense heat that must now be gradually attained, for the proper fusion and refinement of gold.

If the mass of alloy is comparatively pure, it may be immediately refined in the crucible, by first adding thereto from one to four per cent. of nitre, (nitrate of potash,) then from one to five per cent. of borax, and, after it has become thoroughly fluid, some finely pulverized bone-ash should be thrown on its surface. The nitre oxidizes the base metals; the borax, by forming fusible slag with the gangue of iron, etc., will extract and bring such to the surface of the molten metal; whilst the bone-ash, being thrown on a few minutes before pouring into the ingot mould, will absorb the base oxides with the uncombined surplus borax and slag, and otherwise serve to clean the metal and complete the refinement to gold or silver.

B. A large clay crucible, that has been previously used for smelting (if cracked it will answer this purpose) may be rammed with bone-ash, and suitably concaved to retain the alloy. This prepared cupel must be gradually dried, then placed in the furnace and warmed to bright red, when the alloy is put thereon, with sufficient lead to extract the base metals, by oxidation, which will pass away in fumes and into the bone-ash, when the *air is allowed to pass in and over the molten metal*, from the top of the furnace.

The quantity of lead will vary from about one-fourth to ten parts, according to how much the alloy may contain of base metals to be thus oxidized; which should be approximated by a preliminary examination with blow-pipe, or some other method. The appearance of the insufficiently refined metal will also inform you when more lead should be added; which see, under Heading 2, Cupellation.

C. Large sized scorifiers will be found very convenient and effective for the refinement of ordinary quantities of gold, for they can be thus shaped with bone-ash, and the refinement performed in the muffle.

If one is of insufficient capacity, the bullion may be divided, and as many as eight scorifiers can be worked at once, by the double muffle arrangement of the furnace, as illustrated at page 283. (Old scorifiers will do.)

D. SEPARATION OF GOLD AND SILVER FOR REALIZATION.—These operations, that have been so much varied at different places, to suit special commercial circumstances, as to the prices of reagents and sale of resultant products, may be performed by you in two ways, as follows:

Dissolve the alloy of gold and silver (which must contain, or reasons stated at page 339, under Heading 25, at least three arts of silver to one of gold) in a suitable vessel, with boiling itric acid of 1.16 specific gravity, until the sponges or flocks of gold are perfectly freed from silver; then transfer the solid residue of gold, or the nitrate of silver solution, into another vessel, for the more complete purification of the gold by water-washing, and subsequent fusion, for the purpose of its being cast into an ingot, whilst the silver is precipitated as a chloride by common salt, from the solution, which may be fluxed—after the manner suggested by Gay Lussac, and used by Dr. Miller—by mixing to every 100 parts of the chloride, 70.4 parts of carbonate of lime (say chalk, marble or calc), and 4.2 parts of charcoal. It must be warmed to dull redness, and kept so for a half-hour; then the temperature is increased to bright red, when a mass of pure silver is produced.

Gmelin advises to flux with one part of resin to three parts of the dried chloride, which are intimately mixed and packed into a crucible, to half fill it. A moderate heat is first applied, which gradually burns the resin; the heat is then raised to light red, when, the cover being first removed, a little borax is added, the contents are heated to more perfect fluidity, and the crucible removed from the fire. The masses of silver produced may be again fused with borax, and poured into moulds of any desired shape.

E. The alloy may be dissolved in boiling sulphuric acid, and the silver then precipitated by copper, to metallic condition; whilst the copper, being thus brought into the solution as sulphate, will also become valuable to you, or can be sold in local markets. The metallic gold and silver can be collected, fluxed, smelted in crucible, and run into moulds, as before.

G. H. Makins, an assayer in the Bank of England, described, in his Manual of Metallurgy, the following method for producing pure silver and gold, which may sometimes suit the more extensive requirements of the miller:

"To prepare it, coarse silver is dissolved in nitric acid, somewhat dilute; when all is dissolved but associated gold, a further quantity of hot water is added, and the whole allowed to stand until the gold has completely subsided; the nitrate of silver is then to be poured off carefully, and an excess of common salt added so as to precipitate all the silver as chloride. After subsidence, the acid liquid is decanted, and the chloride well washed with repeated quantities of hot distilled water, until the latter is free from acid. The chloride is then acidulated with hydro-chloric acid, added in the proportion of about one pint to each ten pounds of chloride. Into this mud a number of plates of clean wrought iron are put. A copious evolution of hydrogen is at once set up at the surface of the iron, and the solution of the latter commencing, the chloride of silver adjacent to the slips is reduced, and this reduction will spread from each slip of iron throughout the whole, which will thus become a spongy mass of silver. The silver should not be disturbed till all is reduced, or portions of chloride are apt to escape reduction. When all traces of chloride are gone, the iron is carefully removed, the chloride of iron solution poured off, and the whole mass covered with a quantity of hot water, to which about one-tenth its bulk of pure hydro-chloric acid is added. After standing a few minutes, this is poured off and renewed; and, after the decanting of the second portion, pure hot water is added; and, lastly, the whole is washed as quickly as possible with repeated quantities of hot water, until the washings will not render a dilute solution of ferrocyanide of potassium in the smallest degree blue. The silver is then squeezed by the hands, and dried in a porcelain basin. If this process be carefully carried out, it will give a product as fine as 999.7 parts in 1000; that is to say, containing only three-ten-thousandths of admixture, which latter is probably due to peroxide of iron."

THE FOLLOWING TABLES — RANGING, BY UNITS, FROM 1 TO 999 THOUSANDTHS FINE—SHOWING THE MINT VALUES OF GOLD AND SILVER BULLION, AT PER TROY OUNCE, will be regarded as an acquisition to this chapter, as they may be used *after assays for thousandths fine* from any *decimal* weights.

Having ascertained this *fineness*, the total value may be also known by simply multiplying its *opposite relative value* (in the adjoining column) for either gold or silver, by the *whole weight of such bullion in Troy ounces.*

(The fractions of the ounces should be also decimated.)

The *Gold Table* figures may be proven by multiplying the value of a *pure ounce* Troy of gold, or $20.671834625 by your *thousandths fine*, and dividing this product by 1000.

The *Silver table* can be also checked by multiplying $1.29292929 (the worth of an ounce of pure silver) by any one fineness and dividing by 1000.*

You should, however, consider these tables as but theoretical and approximately near the ultimate values; as the buyers will not only test the fineness, but composition; more particularly regarding the values and refractory characteristics of associates, to know the cost of separation, etc.

As a rule, the higher grades are nearer the tables.

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* English readers may first value as above, and then roughly divide by 5 (or the exact decimated number of exchange) to give the relative value in pounds and tenths, or florins.

COMMERCIAL VALUES OF GOLD

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 1 to 199.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
00			00.00	**50**		1	03.36	**100**		2	06.72	**150**		3	10.08
	1		02.07		51	1	05.43		101	2	08.79		151	3	12.14
	2		04.13		52	1	07.49		102	2	10.85		152	3	14.21
	3		06.20		53	1	09.56		103	2	12.92		153	3	16.28
	4		08.27		54	1	11.63		104	2	14.99		154	3	18.35
	5		10.34		55	1	13.70		105	2	17.05		155	3	20.41
	6		12.40		56	1	15.76		106	2	19.12		156	3	22.48
	7		14.47		57	1	17.83		107	2	21.19		157	3	24.55
	8		16.54		58	1	19.90		108	2	23.26		158	3	26.61
	9		18.60		59	1	21.96		109	2	25.32		159	3	28.68
10			20.67	**60**		1	24.03	**110**		2	27.39	**160**		3	30.75
	11		22.74		61	1	26.10		111	2	29.46		161	3	32.82
	12		24.81		62	1	28.17		112	2	31.52		162	3	34.88
	13		26.87		63	1	30.23		113	2	33.59		163	3	36.95
	14		28.94		64	1	32.30		114	2	35.66		164	3	39.02
	15		31.01		65	1	34.37		115	2	37.73		165	3	41.09
	16		33.07		66	1	36.43		116	2	39.79		166	3	43.15
	17		35.14		67	1	38.50		117	2	41.86		167	3	45.22
	18		37.21		68	1	40.57		118	2	43.93		168	3	47.29
	19		39.28		69	1	42.64		119	2	45.99		169	3	49.35
20			41.34	**70**		1	44 70	**120**		2	48.06	**170**		3	51.42
	21		43.41		71	1	46.77		121	2	50 13		171	3	53.49
	22		45.48		72	1	48.84		122	2	52.20		172	3	55.56
	23		47.55		73	1	50.90		123	2	54.26		173	3	57.62
	24		49.61		74	1	52.97		124	2	56.33		174	3	59.69
	25		51.68		75	1	55.04		125	2	58.40		175	3	61.76
	26		53.75		76	1	57.11		126	2	60.46		176	3	63.82
	27		55.81		77	1	59.17		127	2	62.53		177	3	65.89
	28		57.88		78	1	61.24		128	2	64.60		178	3	67.96
	29		59.95		79	1	63.31		129	2	66.67		179	3	70.03
30			62.02	**80**		1	65.37	**130**		2	68.73	**180**		3	72.09
	31		64.08		81	1	67.44		131	2	70.80		181	3	74.16
	32		66.15		82	1	69.51		132	2	72.87		182	3	76.23
	33		68.22		83	1	71.58		133	2	74.94		183	3	78.29
	34		70.28		84	1	73.64		134	2	77.00		184	3	80.36
	35		72.35		85	1	75.71		135	2	79.07		185	3	82.43
	36		74.42		86	1	77.78		136	2	81.14		186	3	84.50
	37		76.49		87	1	79.84		137	2	83.20		187	3	86.56
	38		78.55		88	1	81.91		138	2	85.27		188	3	88.63
	39		80 62		89	1	83.98		139	2	87.34		189	3	90.70
40			82.69	**90**		1	86.05	**140**		2	89.41	**190**		3	92.76
	41		84 75		91	1	88.11		141	2	91.47		191	3	94.83
	42		86.82		92	1	90.18		142	2	93.54		192	3	96.90
	43		88.89		93	1	92.25		143	2	95.61		193	3	98.97
	44		90.96		94	1	94.32		144	2	97.67		194	4	01.03
	45		93.02		95	1	96.38		145	2	99.74		195	4	03.10
	46		95.09		96	1	98.45		146	3	01.81		196	4	05.17
	47		97.16		97	2	00.52		147	3	03.88		197	4	07.24
	48		99 22		98	2	02 58		148	3	05.94		198	4	09.30
	49	1	01.29		99	2	04.65		149	3	08.01		199	4	11.37

COMMERCIAL VALUES OF GOLD

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 200 to 399.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
200		4	13.44	**250**		5	16.80	**300**		6	20.16	**350**		7	23.51
	201	4	15.50		251	5	18.86		301	6	22.22		351	7	25.58
	202	4	17.57		252	5	20.93		302	6	24.29		352	7	27.65
	203	4	19.64		253	5	23.00		303	6	26 36		353	7	29.72
	204	4	21.71		254	5	25 06		304	6	28.42		354	7	31.78
	205	4	23.77		255	5	27.13		305	6	30.49		355	7	33.85
	206	4	25.84		256	5	29.20		306	6	32.56		356	7	35.92
	207	4	27.91		257	5	31.27		307	6	34.63		357	7	37.98
	208	4	29.97		258	5	33.33		308	6	36.69		358	7	40.05
	209	4	32.04		259	5	35.40		309	6	38.76		359	7	42.12
210		4	34.11	**260**		5	37.47	**310**		6	40.83	**360**		7	44.19
	211	4	36.18		261	5	39.53		311	6	42.89		361	7	46.25
	212	4	38.24		262	5	41.60		312	6	44.96		362	7	48.32
	213	4	40.31		263	5	43.67		313	6	57.03		363	7	50 39
	214	4	42.38		264	5	45.74		314	6	49.10		364	7	52.45
	215	4	44.44		265	5	47.80		315	6	51.16		365	7	54 52
	216	4	46.51		266	5	49.87		316	6	53.23		366	7	56.59
	217	4	48.58		267	5	51.94		317	6	55 30		367	7	58.66
	218	4	50.65		268	5	54.01		318	6	57.36		368	7	60.72
	219	4	52.71		269	5	56.07		319	6	59.43		369	7	62.79
220		4	54.78	**270**		5	58.14	**320**		6	61.50	**370**		7	64.86
	221	4	56.85		271	5	60.21		321	6	63.57		371	7	66.93
	222	4	58.91		272	5	62.27		322	6	65.63		372	7	68.99
	223	4	60.98		273	5	64.34		323	6	67.70		373	7	71.06
	224	4	63.05		274	5	66.41		324	6	69.77		374	7	73.13
	225	4	65.12		275	5	68.48		325	6	71.83		375	7	75.19
	226	4	67.18		276	5	70.54		326	6	73.90		376	7	77.26
	227	4	69.25		277	5	72.61		327	6	75.97		377	7	79.32
	228	4	71.32		278	5	74.68		328	6	78.04		378	7	81.39
	229	4	73.39		279	5	76.74		329	6	80.10		379	7	83.46
230		4	75.45	**280**		5	78.81	**330**		6	82.17	**380**		7	85.53
	231	4	77.52		281	5	80.88		331	6	84.24		381	7	87.60
	232	4	79.59		282	5	82.95		332	6	86.30		382	7	89.66
	233	4	81.65		283	5	85.01		333	6	88.37		383	7	91.73
	234	4	83.72		284	5	87 08		334	6	90.44		384	7	93.80
	235	4	85.79		285	5	89.15		335	6	92.51		385	7	95.87
	236	4	87.86		286	5	91.21		336	6	94.57		386	7	97.93
	237	4	89.92		287	5	93.28		337	6	96.64		387	8	00.00
	238	4	91 99		288	5	95.35		338	6	98.71		388	8	02.07
	239	4	94.06		289	5	97.42		339	7	00.78		389	8	04.13
240		4	96.12	**290**		5	99.48	**340**		7	02.84	**390**		8	06.20
	241	4	98.19		291	6	01.55		341	7	04.91		391	8	08.27
	242	5	00.26		292	6	03.62		342	7	06.98		392	8	10.34
	243	5	02.33		293	6	05.68		343	7	09.04		393	8	12.40
	244	5	04.39		294	6	07.75		344	7	11.11		394	8	14.47
	245	5	06.46		295	6	09.82		345	7	13.18		395	8	16.54
	246	5	08.53		296	6	11.89		346	7	15.25		396	8	18.60
	247	5	10.59		297	6	13.95		347	7	17.31		397	8	20.67
	248	5	12.66		298	6	16.02		348	7	19.38		398	8	22.74
	249	5	14.73		299	6	18.09		349	7	21.45		399	8	24.81

COMMERCIAL VALUES OF GOLD

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 400 to 599.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
400		8	26.87	**450**		9	30.23	**500**		10	33.59	**550**		11	36.95
	401	8	28.94		451	9	32.30		501	10	35.66		551	11	39.02
	402	8	31.01		452	9	34.37		502	10	37.73		552	11	41.09
	403	8	33.07		453	9	36.43		503	10	39.79		553	11	43.15
	404	8	35.14		454	9	38.50		504	10	41.86		554	11	45.22
	405	8	37.21		455	9	40.57		505	10	43.93		555	11	47.29
	406	8	39.28		456	9	42.64		506	10	45.99		556	11	49.35
	407	8	41.34		457	9	44.70		507	10	48.06		557	11	51.42
	408	8	43.41		458	9	46.77		508	10	50.13		558	11	53.49
	409	8	45.48		459	9	48.84		509	10	52.20		559	11	55.56
410		8	47.55	**460**		9	50.90	**510**		10	54.26	**560**		11	57.62
	411	8	49.61		461	9	52.97		511	10	56.33		561	11	59.69
	412	8	51.68		462	9	55.04		512	10	58.40		562	11	61.76
	413	8	53.75		463	9	57.11		513	10	60.47		563	11	63.82
	414	8	55.81		464	9	59.17		514	10	62.53		564	11	65.89
	415	8	57.88		465	9	61.24		515	10	64.60		565	11	67.96
	416	8	59.95		466	9	63.31		516	10	66.67		566	11	70.03
	417	8	62.02		467	9	65.37		517	10	68.73		567	11	72.09
	418	8	64.08		468	9	67.44		518	10	70.80		568	11	74.16
	419	8	66.15		469	9	69.51		519	10	72.87		569	11	76.23
420		8	68.22	**470**		9	71.58	**520**		10	74.94	**570**		11	78.29
	421	8	70.28		471	9	73.64		521	10	77.00		571	11	80.36
	422	8	72.35		472	9	75.71		522	10	79.07		572	11	82.43
	423	8	74.42		473	9	77.78		523	10	81.14		573	11	84.50
	424	8	76.49		474	9	79.84		524	10	83.20		574	11	86.56
	425	8	78.55		475	9	81.91		525	10	85.27		575	11	88.63
	426	8	80.62		476	9	83.98		526	10	87.34		576	11	90.70
	427	8	82.69		477	9	86.05		527	10	89.41		577	11	92.76
	428	8	84.75		478	9	88.11		528	10	91.47		578	11	94.83
	429	8	86.82		479	9	90.18		529	10	93.54		579	11	96.90
430		8	88.89	**480**		9	92.25	**530**		10	95.61	**580**		11	98.97
	431	8	90.96		481	9	94.32		531	10	97.67		581	12	01.03
	432	8	93.02		482	9	96.38		532	10	99.74		582	12	03.10
	433	8	95.09		483	9	98.45		533	11	01.81		583	12	05.17
	434	8	97.16		484	10	00.52		534	11	03.88		584	12	07.24
	435	8	99.22		485	10	02.58		535	11	05.94		585	12	09.30
	436	9	01.29		486	10	04.65		536	11	08.01		586	12	11.37
	437	9	03.36		487	10	06.72		537	11	10.08		587	12	13.44
	438	9	05.43		488	10	08.79		538	11	12.14		588	12	15.50
	439	9	07.49		489	10	10.85		539	11	14.21		589	12	17.57
440		9	09.56	**490**		10	12.92	**540**		11	16.28	**590**		12	19.64
	441	9	11.63		491	10	14.99		541	11	18.35		591	12	21.71
	442	9	13.70		492	10	17.05		542	11	20.41		592	12	23.77
	443	9	15.76		493	10	19.12		543	11	22.48		593	12	25.84
	444	9	17.83		494	10	21.19		544	11	24.55		594	12	27.91
	445	9	19.90		495	10	23.26		545	11	26.61		595	12	29.97
	446	9	21.96		496	10	25.32		546	11	28.68		596	12	32.04
	447	9	24.03		497	10	27.39		547	11	30.75		597	12	34.11
	448	9	26.10		498	10	29.46		548	11	32.82		598	12	36.18
	449	9	28.17		499	10	31.52		549	11	34.88		599	12	38.24

COMMERCIAL VALUES OF GOLD

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 600 to 79

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	
600		12	40.31	**650**		13	43.67	**700**		14	47.03	**750**		15	50
	601	12	42.38		651	13	45.74		701	14	49.10		751	15	52
	602	12	44.44		652	13	47.80		702	14	51.16		752	15	54
	603	12	46.51		653	13	49.87		703	14	53.23		753	15	56
	604	12	48.58		654	13	51.94		704	14	55.30		754	15	58.
	605	12	50.65		655	13	54.01		705	14	57.36		755	15	60.
	606	12	52.71		656	13	56.07		706	14	59.43		756	15	62
	607	12	54.78		657	13	58.14		707	14	61.50		757	15	64.
	608	12	56.85		658	13	60.21		708	14	63.57		758	15	66.
	609	12	58 91		659	13	62.27		709	14	65.63		759	15	68
610		12	60.98	**660**		13	64.34	**710**		14	67.70	**760**		15	71
	611	12	63.05		661	13	66.41		711	14	69.76		761	15	73
	612	12	65.12		662	13	68.48		712	14	71.83		762	15	75.
	613	12	67.18		663	13	70.54		713	14	73.90		763	15	77.
	614	12	69.25		664	13	72.61		714	14	75.97		764	15	79.3
	615	12	71.32		665	13	74.68		715	14	78.04		765	15	81.40
	616	12	73.39		666	13	76.74		716	14	80.10		766	15	83.46
	617	12	75.45		667	13	78.81		717	14	82.17		767	15	85 53
	618	12	77.52		668	13	80.88		718	14	84.24		768	15	87.60
	619	12	79.59		669	13	82.95		719	14	86.30		769	15	89.66
620		12	81.65	**670**		13	85.01	**720**		14	88.37	**770**		15	91 73
	621	12	83.72		671	13	87.08		721	14	90.44		771	15	93.80
	622	12	85.79		672	13	89.15		722	14	92.51		772	15	95.87
	623	12	87.86		673	13	91.21		723	14	94.57		773	15	97.93
	624	12	89.92		674	13	93.28		724	14	96.64		774	16	00.00
	625	12	91.99		675	13	95.35		725	14	98.71		775	16	02.07
	626	12	94.06		676	13	97.42		726	15	00.78		776	16	04.13
	627	12	96.12		677	13	99.48		727	15	02.84		777	16	06.20
	628	12	98.19		678	14	01.55		728	15	04.91		778	16	08.27
	629	13	00.26		679	14	03.62		729	15	06.98		779	16	10.34
630		13	02.33	**680**		14	05.68	**730**		15	09.04	**780**		16	12.40
	631	13	04.39		681	14	07.75		731	15	11.11		781	16	14.47
	632	13	06.46		682	14	09.82		732	15	13.18		782	16	16.54
	633	13	08.53		683	14	11.89		733	15	15.25		783	16	18.60
	634	13	10.59		684	14	13.95		734	15	17.31		784	16	20.67
	635	13	12.66		685	14	16.02		735	15	19.38		785	16	22.74
	636	13	14.73		686	14	18.09		736	15	21 45		786	16	24.81
	637	13	16.80		687	14	20 16		737	15	23.51		787	16	26.87
	638	13	18.86		688	14	22.22		738	15	25.58		788	16	28.94
	639	13	20.93		689	14	24.29		739	15	27.65		789	16	31.01
640		13	23.00	**690**		14	26.36	**740**		15	29.72	**790**		16	33.07
	641	13	25.06		691	14	28.42		741	15	31.78		791	16	35.14
	642	13	27.13		692	14	30.49		742	15	33.85		792	16	37.21
	643	13	29.20		693	14	32.56		743	15	35.92		793	16	39.28
	644	13	31.27		694	14	34.63		744	15	37.98		794	16	41.34
	645	13	33 33		695	14	36.69		745	15	40.05		795	16	43.41
	646	13	35.40		696	14	38.76		746	15	42.12		796	16	45.48
	647	13	37.47		697	14	40.83		747	15	44.18		797	16	47.55
	648	13	39.53		698	14	42.89		748	15	46.25		798	16	49 61
	649	13	41.60		699	14	44.96		749	15	48.32		799	16	51.68

COMMERCIAL VALUES OF GOLD

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 800 to 999.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
0		16	53.75	**850**		17	57.11	**900**		18	60.46	**950**		19	63.82
	801	16	55.81		851	17	59.17		901	18	62.53		951	19	65.89
	802	16	57.88		852	17	61.24		902	18	64.60		952	19	67.96
	803	16	59.95		853	17	63.31		903	18	66.67		953	19	70.03
	804	16	62.02		854	17	65.37		904	18	68.73		954	19	72.09
	805	16	64.08		855	17	67.44		905	18	70.80		955	19	74.16
	806	16	66.15		856	17	69.51		906	18	72.87		956	19	76.23
	807	16	68.22		857	17	71.58		907	18	74.94		957	19	78.29
	808	16	70.28		858	17	73.64		908	18	77.00		958	19	80.36
	809	16	72.35		859	17	75.71		909	18	79.07		959	19	82.43
10		16	74.42	**860**		17	77.78	**910**		18	81.14	**960**		19	84.50
	811	16	76.49		861	17	79.84		911	18	83.20		961	19	86.56
	812	16	78.55		862	17	81.91		912	18	85.27		962	19	88.63
	813	16	80.62		863	17	83.98		913	18	87.34		963	19	90.70
	814	16	82.69		864	17	86.05		914	18	89.41		964	19	92.76
	815	16	84.75		865	17	88.11		915	18	91.47		965	19	94.83
	816	16	86.82		866	17	90.18		916	18	93.54		966	19	96.90
	817	16	88.89		867	17	92.25		917	18	95.61		967	19	98.97
	818	16	90.96		868	17	94.32		918	18	97.67		968	20	01.03
	819	16	93.02		869	17	96.38		919	18	99.74		969	20	03.10
20		16	95.09	**870**		17	98.45	**920**		19	01.81	**970**		20	05.17
	821	16	97.16		871	18	00.52		921	19	03.88		971	20	07.23
	822	16	99.22		872	18	02.58		922	19	05.94		972	20	09.30
	823	17	01.29		873	18	04.65		923	19	08.01		973	20	11.37
	824	17	03.36		874	18	06.72		924	19	10.08		974	20	13.44
	825	17	05.43		875	18	08.79		925	19	12.14		975	20	15.50
	826	17	07.49		876	18	10.85		926	19	14.21		976	20	17.57
	827	17	09.56		877	18	12.92		927	19	16.28		977	20	19.64
	828	17	11.63		878	18	14.99		928	19	18.35		978	20	21.70
	829	17	13.70		879	18	17.05		929	19	20.41		979	20	23.77
830		17	15.76	**880**		18	19.12	**930**		19	22.48	**980**		20	25.84
	831	17	17.83		881	18	21.19		931	19	24.55		981	20	27.91
	832	17	19.90		882	18	23.26		932	19	26.61		982	20	29.97
	833	17	21.96		883	18	25.32		933	19	28.68		983	20	32.04
	834	17	24.03		884	18	27.39		934	19	30.75		984	20	34.11
	835	17	26.10		885	18	29.46		935	19	32.82		985	20	36.18
	836	17	28.17		886	18	31.52		936	19	34.88		986	20	38.24
	837	17	30.23		887	18	33.59		937	19	36.95		987	20	40.31
	838	17	32.30		888	18	35.66		938	19	39.02		988	20	42.38
	839	17	34.37		889	18	37.73		939	19	41.08		989	20	44.44
840		17	36.43	**890**		18	39.79	**940**		19	43.15	**990**		20	46.51
	841	17	38.50		891	18	41.86		941	19	45.22		991	20	48.58
	842	17	40.57		892	18	43.93		942	19	47.29		992	20	50.65
	843	17	42.64		893	18	45.99		943	19	49.35		993	20	52.71
	844	17	44.70		894	18	48.06		944	19	51.42		994	20	54.78
	845	17	46.77		895	18	50.13		945	19	53.49		995	20	56.85
	846	17	48.84		896	18	52.20		946	19	55.56		996	20	58.91
	847	17	50.90		897	18	54.26		947	19	57.62		997	20	60.98
	848	17	52.97		898	18	56.33		948	19	59.69		998	20	63.05
	849	17	55.04		899	18	58.40		949	19	61.76		999	20	65.12

A pure, or full thousand fine, Troy ounce of gold is worth $20.671834625.

COMMERCIAL VALUES OF SILVER

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 1 to 199.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
00			00.00	**50**			06.46	**100**			12.93	**150**			19.3
	1		00.13		51		06.59		101		13.06		151		19.5
	2		00.26		52		06.72		102		13 19		152		19 6
	3		00.39		53		06.85		103		13.32		153		19.7
	4		00.52		54		06.98		104		13.45		154		19.9
	5		00.65		55		07.11		105		13.58		155		20.
	6		00.78		56		07.24		106		13.70		156		20.1
	7		00 90		57		07.37		107		13.83		157		20.3
	8		01.03		58		07.50		108		13.96		158		20.4
	9		01.16		59		07.63		109		14.09		159		20.5
10			01.29	**60**			07.76	**110**			14.22	**160**			20.6
	11		01.42		61		07.89		111		14.35		161		20.8
	12		01.55		62		08.02		112		14.48		162		20.9
	13		01.68		63		08.15		113		14 61		163		21.07
	14		01.81		64		08.27		114		14.74		164		21.20
	15		01.94		65		08.40		115		14 87		165		21.33
	16		02.07		66		08.53		116		15.00		166		21.46
	17		02.20		67		08.66		117		15.13		167		21.59
	18		02.33		68		08 79		118		15.26		168		21.72
	19		02.46		69		08.92		119		15.39		169		21.85
20			02.59	**70**			09 05	**120**			15 52	**170**			21.9
	21		02.72		71		09.18		121		15.64		171		22.11
	22		02 84		72		09.31		122		15.77		172		22.24
	23		02.97		73		09.44		123		15.90		173		22.37
	24		03.10		74		09.57		124		16.03		174		22.50
	25		03.23		75		09.70		125		16.16		175		22.63
	26		03.36		76		09.83		126		16.29		176		22.76
	27		03.49		77		09.96		127		16.42		177		22.8
	28		03.62		78		10.08		128		16.55		178		23.0
	29		03.75		79		10 21		129		16.68		179		23.1
30			03.88	**80**			10.34	**130**			16.81	**180**			23.2
	31		04.01		81		10.47		131		16.94		181		23.4
	32		04.14		82		10.60		132		17.07		182		23.5
	33		04.27		83		10.73		133		17.20		183		23.6
	34		04.40		84		10 86		134		17.33		184		23.7
	35		04.53		85		10 99		135		17.45		185		23.9
	36		04.65		86		11.12		136		17.58		186		24.9
	37		04.78		87		11.25		137		17.71		187		24.1
	38		04.91		88		11.38		138		17.84		188		24.3
	39		05.04		89		11.51		139		17.97		189		24.4
40			05.17	**90**			11.64	**140**			18.10	**190**			24.5
	41		05.30		91		11.77		141		18.23		191		24.6
	42		05.43		92		11 89		142		18.36		192		24.8
	43		05.56		93		12.02		143		18.49		193		24.9
	44		05.69		94		12.15		144		18.62		194		25.0
	45		05.82		95		12.28		145		18.75		195		25.2
	46		05.95		96		12.41		146		18.88		196		25.3
	47		06.08		97		12.54		147		19.01		197		25.4
	48		06.21		98		12.67		148		19.14		198		25.6
	49		06.34		99		12.80		149		19.26		199		25.7

COMMERCIAL VALUES OF SILVER

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 200 to 399.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
200			25.86	**250**			32.32	**300**			38.79	**350**			45.25
	201		25.99		251		32.45		301		38.92		351		45.38
	202		26.12		252		32.58		302		39.05		352		45.51
	203		26.25		253		32.71		303		39.18		353		45.64
	204		26.38		254		32.84		304		39.30		354		45.77
	205		26.50		255		32.97		305		39.43		355		45.90
	206		26.63		256		33.10		306		39.56		356		46.03
	207		26.76		257		33.23		307		39.69		357		46.16
	208		26.89		258		33.36		308		39.82		358		46.29
	209		27.02		259		33.49		309		39.95		359		46.42
210			27.15	**260**			33.62	**310**			40.08	**360**			46.55
	211		27.28		261		33.75		311		40.21		361		46.67
	212		27.41		262		33.87		312		40.34		362		46.80
	213		27.54		263		34.00		313		40.47		363		46.93
	214		27.67		264		34.13		314		40.60		364		47.06
	215		27.80		265		34.26		315		40.73		365		47.19
	216		27.93		266		34.39		316		40.86		366		47.32
	217		28.06		267		34.52		317		40.98		367		47.45
	218		28.19		268		34.65		318		41.11		368		47.58
	219		28.32		269		34.78		319		41.24		369		47.71
220			28.44	**270**			34.91	**320**			41.37	**370**			47.84
	221		28.57		271		35.04		321		41.50		371		47.97
	222		28.70		272		35.17		322		41.63		372		48.10
	223		28.83		273		35.30		323		41.76		373		48.23
	224		28.96		274		35.43		324		41.89		374		48.36
	225		29.09		275		35.56		325		42.02		375		48.48
	226		29.22		276		35.68		326		42.15		376		48.61
	227		29.35		277		35.81		327		42.28		377		48.74
	228		29.48		278		35.94		328		42.41		378		48.87
	229		29.61		279		36.07		329		42.54		379		49.00
230			29.74	**280**			36.20	**330**			42.67	**380**			49.13
	231		29.87		281		36.33		331		42.80		381		49.26
	232		30.00		282		36.46		332		42.93		382		49.39
	233		30.13		283		36.59		333		43.05		383		49.52
	234		30.25		284		36.72		334		43.18		384		49.65
	235		30.38		285		36.85		335		43.31		385		49.78
	236		30.51		286		36.98		336		43.44		386		49.91
	237		30.64		287		37.11		337		43.57		387		50.04
	238		30.77		288		37.24		338		43.70		388		50.17
	239		30.90		289		37.37		339		43.83		389		50.29
240			31.03	**290**			37.49	**340**			43.96	**390**			50.42
	241		31.16		291		37.62		341		44.09		391		50.55
	242		31.29		292		37.75		342		44.22		392		50.68
	243		31.42		293		37.88		343		44.35		393		50.81
	244		31.55		294		38.01		344		44.48		394		50.94
	245		31.68		295		38.14		345		44.61		395		51.07
	246		31.81		296		38.27		346		44.74		396		51.20
	247		31.94		297		38.40		347		44.86		397		51.33
	248		32.06		298		38.53		348		44.99		398		51.46
	249		32.19		299		38.66		349		45.12		399		51.59

COMMERCIAL VALUES OF SILVER

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 400 to 599.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
400			51.72	**450**			58.18	**500**			64.65	**550**			71.11
	401		51.85		451		58.31		501		64.78		551		71.24
	402		51.98		452		58.44		502		64.91		552		71.37
	403		52.11		453		58.57		503		65.03		553		71.50
	404		52 23		454		58.70		504		65.16		554		71.63
	405		52.36		455		58.83		505		65.29		555		71.76
	406		52.49		456		58.96		506		65.42		556		71.89
	407		52.62		457		59.09		507		65.55		557		72.02
	408		52.75		458		59.22		508		65.68		558		72.15
	409		52.88		459		59.35		509		65.81		559		72.27
410			53.01	**460**			59.47	**510**			65.94	**560**			72.40
	411		53.14		461		59.60		511		66.07		561		72.53
	412		53.27		462		59.73		512		66.20		562		72.66
	413		53.40		463		59.86		513		66.33		563		72.79
	414		53.53		464		59.99		514		66.46		564		72.92
	415		53.66		465		60.12		515		66.59		565		73.05
	416		53.79		466		60.25		516		66 72		566		73.18
	417		53.92		467		60.38		517		66.84		567		73.31
	418		54.04		468		60.51		518		66.97		568		73.44
	419		54.17		469		60.64		519		67.10		569		73.56
420			54.30	**470**			60.77	**520**			67.23	**570**			73.69
	421		54.43		471		60.90		521		67.36		571		73.82
	422		54.56		472		61.03		522		67.49		572		73.95
	423		54.69		473		61.15		523		67.62		573		74.08
	424		54.82		474		61 28		524		67.75		574		74.21
	425		54.95		475		61.41		525		67.88		575		74.34
	426		55.08		476		61.54		526		68.01		576		74.47
	427		55.21		477		61.67		527		68.14		577		74.60
	428		55.34		478		61.80		528		68.27		578		74.73
	429		55.47		479		61.93		529		68.40		579		74.86
430			55.60	**480**			62.06	**530**			68.53	**580**			74.99
	431		55.73		481		62.19		531		68.65		581		75.12
	432		55.85		482		62.32		532		68.78		582		75.25
	433		55.98		483		62.45		533		68.91		583		75.38
	434		56.11		484		62.58		534		69.04		584		75.51
	435		56.24		485		62.71		535		69.17		585		75.64
	436		56.37		486		62.84		536		69.30		586		75.77
	437		56.50		487		62.97		537		69.43		587		75.89
	438		56.63		488		63.09		538		69.56		588		76.02
	439		56.76		489		63.22		539		69.69		589		76.15
440			56.89	**490**			63.35	**540**			69.82	**590**			76.28
	441		57.02		491		63.48		541		69.95		591		76.41
	442		57.15		492		63.61		542		70.08		592		76.54
	443		57.28		493		63.74		543		70.21		593		76.67
	444		57.41		494		63.87		544		70.34		594		76.80
	445		57.54		495		64.00		545		70.46		595		76.93
	446		57.66		496		64.13		546		70.59		596		77.06
	447		57.79		497		64.26		547		70.72		597		77.19
	448		57.92		498		64.39		548		70.85		598		77.32
	449		58.05		499		64.52		549		70.98		599		77.45

COMMERCIAL VALUES OF SILVER

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 600 to 799.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
600			77.58	**650**			84.04	**700**			90.51	**750**			96.97
	601		77.71		651		84.17		701		90.63		751		97.10
	602		77.83		652		84.30		702		90.76		752		97.23
	603		77.96		653		84.43		703		90.89		753		97.36
	604		78.09		654		84.56		704		91.02		754		97.49
	605		78.22		655		84.69		705		91.15		755		97.62
	606		78.35		656		84.82		706		91.28		756		97.75
	607		78.48		657		84.95		707		91.41		757		97.87
	608		78.61		658		85.07		708		91.54		758		98.00
	609		78.74		659		85.20		709		91 67		759		98.13
610			78.87	**660**			85.33	**710**			91.80	**760**			98.26
	611		79.00		661		85.46		711		91.93		761		98.39
	612		79.13		662		85 59		712		92.06		762		98.52
	613		79.26		663		85.72		713		92.19		763		98.65
	614		79.39		664		85.85		714		92.32		764		98.78
	615		79.52		665		85.98		715		92.44		765		98.91
	616		79.64		666		86.11		716		92.57		766		99.04
	617		79.77		667		86.24		717		92.70		767		99.17
	618		79.90		668		86.37		718		92.83		768		99.30
	619		80 03		669		86.50		719		92.96		769		99.43
620			80.16	**670**			86.63	**720**			93.09	**770**			99.56
	621		80.29		671		86.76		721		93.22		771		99.68
	622		80.42		672		86.88		722		93.35		772		99.81
	623		80.55		673		87.01		723		93.48		773		99.94
	624		80.68		674		87.14		724		93.61		774	1	00.07
	625		80.81		675		87.27		725		93.74		775	1	00.20
	626		80.94		676		87.40		726		93.87		776	1	00.33
	627		81.07		677		87.53		727		94.00		777	1	00.46
	628		81.20		678		87.66		728		94.13		778	1	00.59
	629		81.33		679		87.79		729		94.25		779	1	00.72
630			81.45	**680**			87.92	**730**			94.38	**780**		1	00.85
	631		81 58		681		88 05		731		94.51		781	1	00.98
	632		81.71		682		88.18		732		94.64		782	1	01.11
	633		81.84		683		88 31		733		94.77		783	1	01.24
	634		81.97		684		88.44		734		94.90		784	1	01.37
	635		82.10		685		88.57		735		95.03		785	1	01.49
	636		82.23		686		88.69		736		95.16		786	1	01.62
	637		82.36		687		88.82		737		95.29		787	1	01.75
	638		82.49		688		88.95		738		95.42		788	1	01.88
	639		82.62		689		89.08		739		95 55		789	1	02.01
640			82.75	**690**			89.21	**740**			95.68	**790**		1	02.14
	641		82.88		691		89.34		741		95.81		791	1	02.27
	642		33.01		692		89.47		742		95.94		792	1	02.40
	643		83.14		693		89.60		743		96.06		793	1	02.53
	644		83.26		694		89.73		744		96.19		794	1	02.66
	645		83.39		695		89.86		745		96.32		795	1	02.79
	646		83.52		696		89.99		746		96.45		796	1	02.92
	647		83.65		697		90.12		747		96.58		797	1	03.05
	648		83.78		698		90.25		748		96.71		798	1	03.18
	649		83.91		699		90.38		749		96.84		799	1	03.31

COMMERCIAL VALUES OF SILVER

Per (480 grains) Troy ounce, at from 1 to 999-thousandths fine.

From 800 to 999.

	Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.		Fine.	Dollars.	Cents.
800		1	03.43	**850**		1	09.90	**900**		1	16.36	**950**		1	22.83
	801	1	03.56		851	1	10.03		901	1	16.49		951	1	22.96
	802	1	03.69		852	1	10.16		902	1	16.62		952	1	23.09
	803	1	03.82		853	1	10.29		903	1	16.75		953	1	23.22
	804	1	03.95		854	1	10.42		904	1	16.88		954	1	23.35
	805	1	04.08		855	1	10.55		905	1	17.01		955	1	23.47
	806	1	04 21		856	1	10.67		906	1	17.14		956	1	23.60
	807	1	04.34		857	1	10 80		907	1	17.27		957	1	23.73
	808	1	04.47		858	1	10.93		908	1	17.40		958	1	23.86
	809	1	04.60		859	1	11.06		909	1	17.53		959	1	23.99
810		1	04.73	**860**		1	11.19	**910**		1	17.66	**960**		1	24.12
	811	1	04.86		861	1	11.32		911	1	17.79		961	1	24.25
	812	1	04.99		862	1	11.45		912	1	17.92		962	1	24.38
	813	1	05.12		863	1	11.58		913	1	18.04		963	1	24.51
	814	1	05.24		864	1	11.71		914	1	18.17		964	1	24.64
	815	1	05.37		865	1	11.84		915	1	18.30		965	1	24 77
	816	1	05.50		866	1	11.97		916	1	18.43		666	1	24.90
	817	1	05.63		867	1	12.10		917	1	18.56		967	1	25.03
	818	1	05.76		868	1	12.23		918	1	18.69		968	1	25.16
	819	1	05.89		869	1	12.36		919	1	18.82		969	1	25.28
820		1	06.02	**870**		1	12.48	**920**		1	18.95	**970**		1	25.41
	821	1	06.15		871	1	12.61		921	1	19.08		971	1	25.54
	822	1	06.28		872	1	12.74		922	1	19.21		972	1	25.67
	823	1	06.41		873	1	12.87		923	1	19.34		973	1	25.80
	824	1	06.54		874	1	13.00		924	1	19.47		974	1	25.93
	825	1	06.07		875	1	13.13		925	1	19.60		975	1	26.06
	826	1	06.80		876	1	13.26		926	1	19.73		976	1	26.19
	827	1	06.93		877	1	13.39		927	1	19.85		977	1	26.32
	828	1	07.05		878	1	13.52		928	1	19.98		978	1	26.45
	829	1	07.18		879	1	13.65		929	1	20.11		979	1	26.58
830		1	07.31	**880**		1	13.78	**930**		1	20.24	**980**		1	26.71
	831	1	07 44		881	1	13.91		931	1	20.37		981	1	26.84
	832	1	07.57		882	1	14.04		932	1	20.50		982	1	26.97
	833	1	07.70		883	1	14.17		933	1	20.63		983	1	27.09
	834	1	07.83		884	1	14.29		934	1	20.76		984	1	27.22
	835	1	07.96		885	1	14.42		935	1	20.89		985	1	27.35
	836	1	08 09		886	1	14.55		936	1	21.02		986	1	27.48
	837	1	08.22		887	1	14.68		937	1	21.15		987	1	27.61
	838	1	08.35		888	1	14 81		938	1	21.28		988	1	27.74
	839	1	08.48		889	1	14.94		939	1	21.41		989	1	27.87
840		1	08.61	**890**		1	15.07	**940**		1	21.54	**990**		1	28.00
	841	1	08.74		891	1	15.20		941	1	21.66		991	1	28.13
	842	1	08.86		892	1	15.33		942	1	21.79		992	1	28.26
	843	1	08.99		893	1	15.46		943	1	21.92		993	1	28.39
	844	1	09.12		894	1	15.59		944	1	22.05		994	1	28 52
	845	1	09.25		895	1	15.72		945	1	22.18		995	1	28.65
	846	1	09.38		896	1	15.85		946	1	22.31		996	1	28.78
	847	1	09.51		897	1	15.98		947	1	22.44		997	1	28.91
	848	1	09.64		898	1	16.11		948	1	22.57		998	1	29.03
	849	1	09.77		899	1	16.23		949	1	22.70		999	1	29.16

The value of one Troy ounce of pure (thousand fine) silver is $1.29292929, etc.

CHAPTER IX.

ASSAYING OF LEAD.

1. **By Crucible.**—The ores of lead can be assayed for percentage more promptly than those of gold and silver, per ton; but if accuracy is essential, great care must be taken to understand the constitution of the mineral, unless this deficiency of knowledge for exact fluxation is rendered unnecessary, by relying on the universal action of, and chemical changes produced by fire, during fifteen minutes preliminary roasting at a *low red heat.*

All lead ores which are valuable to miners, when thus roasted, as well as those several ores of carbonate, chromate, phosphate and oxide of lead, which do not require it, may be fluxed and smelted in the following manner:

A. Average your sample with great care; take 25 grains of ore and 50 grains of carbonate of soda, which intimately mix and then drop them, by aid of a long-handled scoop, into your *red-hot* crucible; quickly cover these with 50 grains of carbonate of soda, and close the furnace for about twenty minutes, when you may remove the crucible from the fire, tap it lightly, to precipitate and unite the molten globules of lead, and after it becomes quite cold, it may be broken for extraction of the button, which must be brushed clean and weighed. Multiply this weight by 4 for percentage of metal from the 25 grains of ore.

In assays of importance you should never rely on one, but make say three, of 18, 20 and 22 minutes, and record the highest result, from the most suitable time. The heat should be a little higher than red.

When properly conducted, this will extract as much lead, from all classes of ores, as any other mode; and, although sulphuret of antimony may be present, very little will be reduced by these fluxes, as it will volatilize and combine to form slag. I have observed that molten lead, when carbon is present, will *in a* *manner amalgamate with* a little antimony, which makes it crack on the thin edge when the button is rolled or hammered into a broad sheet.

The sulphuret of antimony is often associated with that of lead, throughout the Western States and Territories of North America; but even then, this mode will be found quite sufficient, if you will use the precaution of re-melting this button, once or twice on charcoal before the flame of the blow-pipe, and stop blowing just when it becomes quite fluid; as this allows the very little antimony which the lead retained, to more freely pass off as a white oxide smoke.

For ordinary purposes, even the worst ore, that of sulphuret of lead, (galena,) need not be roasted.

When antimony is present, an iron crucible must not be used, as it also *reduces the sulphuret of antimony to metal.*

B. Should it be required to ascertain the percentage of lead and antimony, the *same quantity of ore may be treated as above for lead;* but, for both lead and antimony: to this end, the 25 grains of ore must be fused with an intimate mixture of 75 grains of carbonate of soda, and 75 grains of cyanide of potassium, which will reduce both metals; and this weight, multiplied by 4, will be the percentage of alloy, whilst, the former percentage of lead being deducted therefrom, the difference will give the weight of antimony.

Pure lead will flatten to a very thin disk without cracking its edges, and it may be even then repeatedly bent across the middle without fracture.

The above modes are universal and reliable for all the ores of lead which are of any value to the miner.

There are several other methods practiced in different districts for assaying pure galena; but they require *much discretion,* where there is any chance for *associations with antimony, etc.,* or errors will be the result.

A carefully averaged sample may be much more conveniently smelted in muffle, from even ten grains in a suitably small crucible; but, if more is taken, the larger crucible will require an open fire.

If copper is present in the ore, a more moderate heat, and less time, may be advantageously given, so that as little copper as possible may be reduced.

2. ASSAYING OF LEAD AND ANTIMONIAL LEAD ORES, BY THE "WEE PET" MACHINE.

A. Carefully prepare the sample for average, as directed in Chapter I, Section III, for all other assays.

B. Balance the lever with weight A, so that the *pointer* of the *main lever* may lie opposite the *line* on the end of the *transverse lever*.

C. Carefully remove weight A from the scale scoop, and place the weight marked B therein, in the manner described under headings A, B, C, D, E, F, G, and H, pages 307, 308, and 309.

D. Shovel the ore into the other end of the scale scoop, until the *weight B and this ore* bring the *pointer* of the *main lever* again to balance with the line on the cross lever, and it will conform to the quantity marked 1000 against weight marked X 4, in the No. 4 column, under the calculating lever.

E. Return weight B to the weight-box, unhook the scoop, and drop the weighed sample into the concavity of a prepared charcoal assaying-cup, prepared by means explained under the silver assay, and then you may cover it with 10 grains of carbonate of soda, as obtained by one balancing, after weight A has been removed from the pan. These should be mixed just as thoroughly as possible, as it will greatly assist the reduction, and obtain a higher percentage from the same ore.

F. If pure lead is required, the lamps may be now lighted, and the sample almost covered by a piece of solid charcoal, (properly clasped in, and suspended by, the spring-fingers, as seen at page 172, by Figure 21,) or partially covered by a furnace of fire suspended thereover, (as shown by Figure 28, page 307,) and smelted for some ten or fifteen minutes, as described under headings T, U, V, W, pages 314, 315, on the Silver Assay by "Wee Pet" machine.

G. Remove the resultant button of lead from the support, clean off the slag, and balance it with one of the numbered weights, marked X 3, X 4, (as explained at page 319, under Heading Z 1,) and the button by lying opposite its fraction of 100 will thus expose its thousandths at sight.

Decimate the last right-hand figure (or divide by 10), and percentage may be also known.

Thus, say with weight X 4, in the scale scoop, the butt balanced just opposite 800, in No. 4 column; this would be 8 per cent.

If, at another time, it balanced with weight X 3, (in the sc scoop,) opposite 180, in No. 3 column, this would, when de mated, equal 18. per cent., which is sufficiently low for practi purposes. If, however, you would value still lower, use weights marked 4, 3, 2, and 1, and decimate two right-han figures.

H. If antimony is also required, take the same weight of as before, but flux with one balancing (10 grains) of carbona soda, and with another balancing of the cyanide of potassi when the total will represent the alloy of lead and antimony, the *difference* of the percentage of these buttons, produced fr the separate fluxings, will, with the same precaution as for crucible assay, give the percentage of antimony.

3. ASSAYING OF LEAD AND ANTIMONIAL LEAD BY THE COM BLOW-PIPE.

A. *For obtaining pure lead*, take one grain of pulverized and two grains of carbonate of soda, which intimately mix gether, then after covering it with another two grains of carb-nate of soda, smelt in a paper cartridge for from six to eig-minutes, *in* a good yellow reducing flame, as fully described der heading 13, page 294, for the Assaying of Silver by Comm Blow-pipe, or at page 212, for assaying lead by *my more si and efficient* method.

Clean the button from slag, and hammer it very thin; if edges are free from cracks, and the disks can be repeatedly across the middle without breaking, the metal is sufficiently if not, re-place it on the charcoal, and warm it with an inter-tent flame, but just to molten state, for a few seconds, so any slight traces of the more volatile white oxides of zinc o-timony may pass off, and repeat the tests of flattening, etc., pure lead is thus obtained.

B. If antimony is present in quantity, flux with an intimate ixture of one grain of carbonate of soda and one grain of cyade of potassium, which cartridge with the same quantity of ch flux to cover, and smelt, as before, for from six to eight inutes.

This cleaned button will contain *both the lead and antimony*, and he weight of lead from A, being deducted from that of the alloy rom B, the quantity of *each can be known.*

With a good balance, a carefully averaged sample may be thus ost readily assayed; and the good blow-pipist requires no better eans than this for the ordinary practical purposes of mining nd reducing lead and antimonial ores.

The percentage-calculating lever, illustrated by Figure 38, Chapter XI, under the heading for "*Assaying Copper by the Common Blow-Pipe,*" will be very useful for general practical purposes, as it may be easily made by ordinary hands, and suits *any weight of ore* taken for assay, when the resultant button is balanced on the longer end, against such weight in the pan; and the "Little Wonder" of Figure 24, page 202, *will be still more correct* and serviceable.

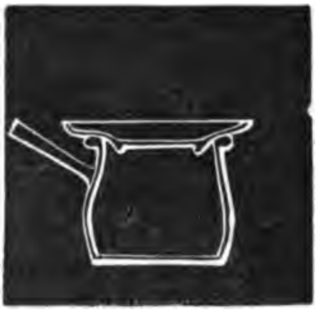
4. ASSAYING OF LEAD BY WATER CONCENTRATION.

A. Galena (or sulphuret of lead) is found in very many mines, in a state of complete isolation from antimony and other heavy minerals; and, where such occurs, a more accurate, economical, and expeditious assay can be made by water concentration, for its equivalent quantity of metallic lead, than by any other method whatever. This may be accomplished in the following manner:

Take 1000 grains from an average sample prepared after the method of Chapter I of this Section, and carefully concentrate it thrice, by the manner fully explained in Chapter III, at page 164; after the several concentrations are collected in a plate, saucer, bowl, or other suitable vessel, it may be thoroughly and safely dried, at boiling temperature, by placing the pan or saucer, *as a lid*, over a sauce-pan or coffee-pot of boiling water, (as shown by Figure 35.)

This dried residue may be next transferred to a *previously balanced* paper, and weighed for its percentage of galena, which, being multiplied by 86.55 and divided by 100, (or more simpl multiplied by the decimal numbers .8655,) its actual percentag of metallic lead will be ascertained; and this dried weight ma

Figure 35.



be also multiplied by 4 and divided by 5, so as to ascertain the lesser quantity that can be obtained from crucible assay, or more extensive smelting operations.

If a little metallic or magnetic iron or copper should be present, the former can be extracted by the magnet, and both may be dissolved away from the concentrated ore, before it is dried, in a few drops of diluted sulphuric acid.

This method gives proper credit to, and calculates from, the precipitate produced by natural formation, without any assistance from those more tedious and difficult artificial manipulations, which require much more time, knowledge, attention, and expensive tools.

In lead mines yielding other ores, it will be frequently found sufficiently near for the daily *working purposes* of the miner, to first ascertain *how much metallic lead can be obtained from* 100 *grains of a thoroughly concentrated sample of such ore, by crucible assay;* and, instead of using the former multiplier for galena, to *substitute the one thus created for his individual purpose,* to ascertain the produce of such impure, yet sufficiently equable, ores.

There are no *very easy* and *reliable* methods, suitable for your purposes, for the assaying of lead ores by acids, etc., unless you have some chemical knowledge, and the facilities afforded by a laboratory; and, seeing that the above more appropriate methods are always at hand, it will be unnecessary to describe any of the far-fetched, chemical modes.

CHAPTER X.

ASSAYING OF ANTIMONY.

1. **By Crucible.**—There are many uncertain fluxes used for ssaying antimony, and one that is more efficient and trustworthy han all others; it, however, has the disadvantages of being more xpensive and scarce. I have endeavored to reduce the numer of fluxes as much as possible, and when certainty and effiiency are not endangered, to simplify the operations of assaying; nd as this flux greatly favors these intentions, by reacting in a nanner not only peculiar to itself, but superior to all others; the trifling difference of its cost should not prevent its use, when so preëminently serviceable. For your occasional purposes, even this disadvantage is much modified by the fact, that many others are thus rendered unnecessary.

To 100 grains of the nearly pure, well averaged pulverized sample, add 300 grains of cyanide of potassium, or in proportion to the sample—as ascertained by water concentration and calculating scales, on the antimony line, at page 277, as it also happens, like nitre, to require just 300—it may be then thoroughly mixed, tranferred to a crucible, and placed in a moderately hot fire. It should be closely watched, and, in *ten minutes after it has arrived at a red heat*, it may be withdrawn from the fire, and either quickly poured into an iron mould, or allowed to get cold in its place, when it may be extracted by fracturing the crucible, then cleaned and weighed for percentage.

If close results are required, it will be necessary to give different times, as ten, twelve and fourteen minutes, and see that they shall scarcely exceed a red heat.

2. **When Galena is also Present.**—It must be fluxed in pro-

portion, as at page 360, for the ratio of both metals; then sme ed, and calculated for each, as there directed.

3. The Assay of Antimony by Blow-pipe.—This is not re able when pure antimonial ore is treated; but, when somewh mixed with lead as an alloy, the mutual affinity greatly helps, an it may be then more correctly reduced, as at page 360, und "Lead and Antimony."

4. Assay of Antimony by Machine.—When mixed with consi erable lead, it is more practical than by common blow-pipe, a may be smelted in very similar manner, and fluxed as at pa 360, for such alloy.

5. Assay of Sulphuret of Antimony by Water.—When fr from other minerals, it may be concentrated, as fully descri at page 163, and under Heading 4, page 363, for the "Le Assay;" dried also, as shown by Figure 35; and the percenta of metal may be known by multiplying it by .73. In working mine, any peculiar multiplier may be obtained as *under lead*, f approximate working purposes.

So, also, for ordinary practical purposes on the same mi from similar ores, advantage may be taken from its extraordinar volatilization under the action of heat, after which comparison from actual assays may be made and tabled for reference whe required; thus, if a sample of 100 grains of sulphuret of antim ny, of known crucible assay percentage of metal, after having been placed in a previously balanced or weighed clay scorifie crucible or roasting-cup, should diminish in weight any recorded percentage, after say twenty minutes roasting in a stove or other fire, at a red heat, it will, when tabled in another column, opposite the real assay, serve as a convenient guide for future occasions.

The Humid Assay of Antimony—Is too difficult for amateurs a it can only be correctly performed by experienced chemists, wi ample laboratory facilities.

CHAPTER XI.

ASSAYING OF COPPER.

The methods, both for sampling and assaying copper, have en too much governed by the smelters, who have treated mi-rs just exactly as they thought proper, and therefore the roduce," or percentage, is even to this day more ruled by *nventional minimum modes* than the *real quantity* of copper in e ores. See Chapter I, Section III—on the preparation of the mple—for the *absurdities of this* and superior excellence of the w mode. These assays are made in the following most waste-l manner:

1. **The Assaying of Copper in Crucible, by Cornish Method**— recognized by all the smelters, and may be performed by the llowing fluxes, in the manner now being described.

Common salt, *in its damp state.*
Common salt, *perfectly dry.*
Fluor spar.
Lime.
Borax. (*" Borax glass " is much better.*)
Nitre. (*Nitrate of potash, or saltpetre.*)
Charcoal.
Tartar. (*Cream of tartar, or argol.*)
Sulphur, and sulphuret of iron, quite free from copper.
White flux.
All of these must be pulverized.

The latter you may prepare, when required, by mixing six table-spoonfuls of tartar with four of nitre and one of dry common salt, in a mortar; and then stirring them for a few minutes, with a red-hot iron bar.

Those who would become acquainted with all the several details of the varied mechanical manipulations and chemical reactions produced in the Cornish method for the crucible assay of copper, may consult the elaborate description contained in th large work on Metallurgy, written by John Percy, M. D., F. R. S Lecturer on Metallurgy at the Government School of Mine London; but the following will be sufficient for the requiremen of the miner:

Prepare and pulverize the dried sample for average, in th manner described in Chapter I, Section III, noting the uppe side of the sieve for flattened disks of metallic copper, which, i found, must be calculated separately, as previously described fo gold, silver, etc., from the whole weight of the sample, or thus: If say 1900 grains of sample yielded 23 grains of such copper, what ratio would 100 grains (or any other quantity taken for assay) have yielded? Which may be known by multiplying this weight of 23 grains by the 100 grains (or any other weight taken for sample), and dividing this (product of 2300 grains) by 1900 grains, the total quantity from which the disks were obtained; and as in this case it equals 1.21 per cent., and robs the assay that much, it must be added to the percentage, as directly obtained from the 100 grains, which did pass through the sieve.

To do away with all these tedious collateral manipulations, calculations, etc., unless the copper is in excess, I prefer to completely dissolve these thus obtained disks, in the least possible quantity of sulphuric acid; and then, after diluting the solution a hundred fold with water, to scatter this coppery acid drop by drop throughout the whole pile of ore, before it is dried (so that one drying may suffice); then to completely mix, both before and after, ere the sample is weighed. The more equable result obtained is of greater consequence than the very slight error occasioned by the weight of the few drops of acid thus added to the whole pile, which can, however, be allowed for, if necessary, by taking the proper ratio of ore in addition, when weighing for the assay.*

An excess of the quantity required for assay must be taken, and dried at 212°, the boiling temperature of water, so as to have sufficient surplus for repetition of the assay, in case of accident, and for preliminary examination by water, (as previously deribed in Chapters III, IV and V, Section III, on "Discriminion of Minerals for Practical Purposes," etc.,) to ascertain, in is case, whether it belongs to the class of copper ores denomited by Cornish assayers the "Raw Sample," which contains tle or no sulphur; or to that by them called the "Warm ample," that contains much sulphur, and requires preliminary asting.

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* In gold and silver assays, the former may be thus dissolved by two drops of hydrochloric acid and one of nitric acid; and the latter by nitric acid, then diluting and equally disseminating in similar manner.

The quantity of ore taken for the assaying of copper is varied, cording with the quantity and quality of mineral for metal, as to obtain a button of suitable size, and therefore several of e fluxes remain about the same.

A weight of 400 grains has been chosen to represent a suitable uantity for the poorest ores, which is divided into hundredths, nd again into *eighths of one unit* of such percentages, to represent the market "produce."

or ores under 10 per cent. of copper, 400 grains, or *their* 100 weight, is used.
hose above 10 and under 30 per cent. of copper, 200 grains, or their 50 weight.
res that exceed 30 per cent. of copper, 100 grains, or their 25 weight.

These assays are then performed by the following series of istinctly different operations:

A. ROASTING TO EXPEL THE SULPHUR.—Weigh the dried sample, and, if roasting is required, place it in a crucible about four inches high, so that the ore may have sufficient room for being stirred, without causing it to escape over the edge. Warm it to red heat, stirring it continuously with a small rod of iron; the mouth of the crucible should be slightly above the fuel, and inclined away from the draught-hole leading to the chimney, so that the air may freely enter and oxidize the ore.

The roasting can be completed in from fifteen to thirty minutes, when it should present an earthy, pulverized appearance; but, if such has not been accomplished, another sample should be more effectually roasted.

B. FUSION FOR REGULUS.*—The unroasted, or this *roasted* sample, may be intimately mixed, and fused in the *same* crucible, with equal weights of borax glass, fluor spar, and slacked lime, covered by a layer of common salt.

After the crucible's contents have become *thoroughly molten at a high temperature*, when treating an unroasted sample of very low grade copper pyrites, a little nitre should be added; so, also, when the raw sample does not contain any sulphur, about 20 grains should be given to have sufficient for producing good regulus; then a little lime, fluor spar and borax are again taken, and, when thoroughly fused to fluidity, the contents must be poured into the button mould, when, after it has solidified, it may be dropped into a shallow water-trough, to remain until the adhering slag can be readily separated from the heavy regulus. This must be of a bluish bronze color, with considerable metallic lustre, and generally contains from forty to seventy per cent. of copper.

This button of regulus, which should be medium between dull and bright, must be very finely pulverized in a mortar, with a little charcoal or coke, care being taken that none is lost, either over, or by sticking to the mortar; then transfer it to another similarly sized crucible, for re-oxidation by a second roasting.

C. ROASTING THE REGULUS.—This is effected by placing the crucible on the fire, warming it gradually, during continual stirring with a steel or iron rod, for about twenty-five minutes, until it shows a brownish-black earthy appearance, and all sulphurous fumes have ceased.

D. SMELTING OF THE SULPHIDE REGULUS FOR IMPURE COPPER. Mix (in the same crucible) with this "roasted regulus" 25 grains of nitre (nitrate of potash or saltpetre), 25 grains of borax, 15 grains of coal powder, 100 grains of *dry* salt, and 200 grains of tartar. Cover this well disseminated mixture with a tablespoonful of common salt.

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* In fluxing for regulus, the effects sought are a fusible slag (produced by borax and fluor spar), which shall also contain the copper, etc., when oxidized and fused to sulphide form; hence the addition of sulphur, or sulphuret of iron, to certain ores, which contain no sulphur in their natural constitutional forms.

The lime facilitates the separation of the lighter stratum of the slag from the regulus.

Place the crucible in the fire, covered by a piece of coke or charcoal, and heat it as quickly as possible, for about fifteen minutes, or until perfectly fluid; then, after adding a little white flux, (to oxidize the foreign metals,) and allowing it to remain a few minutes longer, it must be removed from the fire with a quick, circular motion, so as to simultaneously wash any globules of copper from its sides; now lightly tap it on the furnace to precipitate them to the larger button at the bottom, and quickly pour it into the previously well-greased metallic mould; the crucible is now returned to the fire for the next stage of the assay, or the further oxidation of the associated metals, by the process called "Washing."*

E. "Washing," or Fusion with Fluxes.—The impure button from the smelted regulus is now placed in the white-hot crucible, for the further riddance, by oxidation and chloridation, of the associated metals, by the assistance of 100 grains of white flux and 200 grains of dry salt.

The mass should be quickly heated, and after remaining *perfectly fluid* for five or six minutes, be again quickly poured into the iron mould, for further examination by hammer, etc.

It should, when brushed clean, be comparatively pure, or this "washing" must be repeated.

F. Refining the "Washed" Button.—It is first cleaned and hammered thin; if it is then seen to be *hard*, tin is still associated therewith; if it should crack around the edges, antimony; and if in the least yellow, zinc. If of undoubted color, softness, and tenacity, it may be now weighed for percentage; but otherwise, a clean crucible must be properly fixed in the fire, until *white*-hot, and the button placed therein. It should quickly melt to a *hazy* semi-globular shape, but *immediately* the edge loses this appearance, or becomes *very distinct in outline*, and the center shows a *dark variegated* appearance, which should be carefully noticed, an equal (previously prepared) mixture of 50 grains of white flux and dry salt must be promptly added, and after five minutes the molten contents may be poured into the iron mould: the butt should now stand the several tests for pure copper, and b weighed for percentage.

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* In this operation, the salt rendered the mass fusible, and formed various chlorides; the borax served as a flux; the nitre passed off the sulphur; the tartar and coal powder, by forming carbonic oxide, reduced all the oxidized copper to metal; when the addition of white flux disposed of the other associated metals by oxidation.

G. **ALL THE WASTE SLAGS ARE SAVED FROM THESE SEVERAL FUSIONS, AND RE-SMELTED**—In a suitably sized crucible, *for fifte* minutes, with 100 grains of tartar and 20 grains of pulveriz coal or charcoal; after which it is poured into the *mould*, t impure copper again refined, and the weight of this "Pril added to that from the assay proper.

The kinds and quantities of the fluxes given are for gener application, rather than for varying percentages; for *which som* would have to be increased and others diminished as occasio required, so as to economize for the various ores.

It will be almost impossible for an amateur to become ver proficient in this matter, beyond the practice of *varying th* weight of the sample taken for assay, according to the percentage of the supposed metal in the ore, which a practical eye ma closely approximate. The Cornish assayers, although working entirely upon the *more simple copper ores*, each day of their lives, do but approximate to rigidly accurate quantities; as too much time would be required in calculations and weighings for exa chemical proportions.

In fact, this comprehensive manner of assay, *with the fluxes i excess*, will permit more than ordinary irregularity, for the following reasons:

The roasting partially desulphurizes; the several fluxes used for producing greater fusibility are *otherwise harmless*, even when in excess; the sulphide slag is directly produced by the uncontrolled strength of the sulphur's affinity for copper, etc.; the oxidizing fluxes are much restricted by the excessive quantity of those for reducing: the manipulation is therefore much more likely to cause error than the fluxes.

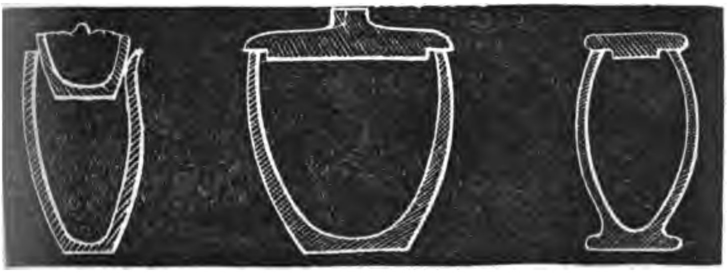
The upper part of the furnace, under the cover H, (as illustrated at page 283,) is also adapted for this copper assay, and the muffles, in addition to scorifying and cupelling gold and silver, can be used for roasting as well as the actual assaying of copper by the German method.

Beyond the deplorable fact that this Cornish mode of assaying is always demanded by the smelters, and that, *apart from the* s, it somewhat resembles smelting on the large scale, there be no other reason for favoring or retaining such a tedious, ult and expensive, unsatisfactory and low percentage method, ssaying.

. **Assaying Copper by the German Method.**—This, the favor- means used in Central Europe for the fire estimation of cop- , having less smelting, etc., is more speedily accomplished; l as it can be performed in the muffle, without the slightest onvenience, instead of the open fire (which requires constant endance), not only a much greater number of assays can be de in the same time, but the work is immediately under the ual supervision of the assayer; it is also more regular in re- lts, and the percentage of copper approaches much closer to e real quantity contained in the ore.

The general-purpose furnace, as illustrated at page 283, will be und very convenient for this purpose, and either stone-coal, ke or charcoal may be used; the greater portion of which must regularly supplied at the top, so as to keep it at about four ches below the cover, H; whilst a little should be occasionally ut through the hole, F, under the muffles, to regulate the heat required. Figure 36 illustrates the crucibles which are adapt- d for these several assays.

Figure 36.



French. Cornish. German.

The expanded-bottom German crucible is best shaped for this work, as it is barrel-sided and stands more safely in the muffle, whilst the bottom of each crucible serves most effectually for covering the next assay. The short but capacious Cornish crucible, when supplied with an especial cover for close assays, will be also found convenient; or the French general-purpose crucible, as shown here and at the right of the scorifier, on the front of the furnace, at page 283, where the wooden-handled iron button-mould, the tongs, and the spring-clip lie.

This German process is divided into the three separate fire treatments of "Roasting," "Smelting for Impure Copper," and "Refining."

The following fluxes and substances are required:

Graphite or charcoal, pulverized.
Common glass, pulverized.
Borax glass, pulverized.
Common salt, dried and pulverized.
Arsenic (metallic).
Black flux.

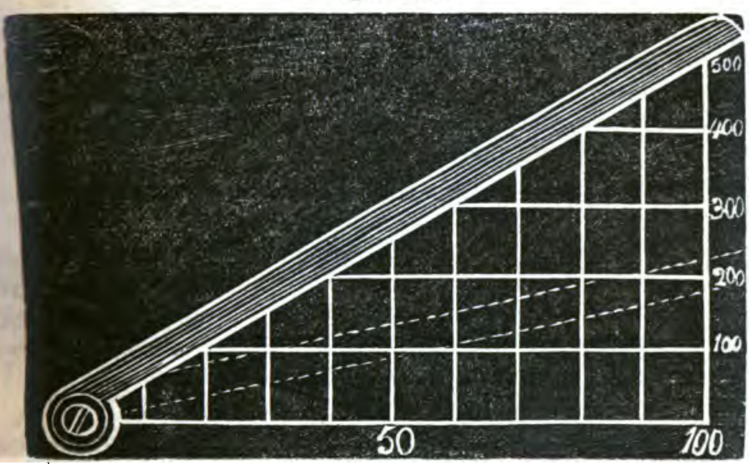
The last may be prepared by *intimately mixing one measure* of granulated nitre to *two measures* of pulverized crude tartar, and stirring them with a red-hot iron wire, in a sufficiently hot and capacious crucible. This flux is formed during the smelting, by the Cornish mode.

A. ROASTING.—As a smaller quantity (60 grains) is taken for the German than for the Cornish assay, just described, you should prepare your sample with still greater care, by the directions given in Chapter I of this Section, so that it shall be perfectly homogeneous.

The same precautions being taken about metallic copper as fully described at page 368, for the "Cornish Assay of Copper," you may weigh out 60 grains of dried ore; mix it with 15 grains of graphite, and spread it over a scorifier or roasting-cup (which has been previously rubbed with red chalk or red ochre, to prevent the adherence of the ore;) then place this one, or more of such similarly-coated vessels, in the muffle or muffles, and carefully roast for fifteen minutes, at red heat, stirring nearly the whole time with a small iron wire; if the ore should still smell of sulphur when taken out and held under the nostrils, it must be re-pulverized, then mixed with 15 additional grains of graphite, and be more thoroughly roasted until the sulphur is completely volatilized.

When this has been well performed, the sample appears earthy and granular; but, otherwise, it has a coarse, clodded, slaggy, or metallic appearance; because the stirring had been neglected, or it exceeded the low red heat just advised for this operation, more particularly when the ore is mixed with some fusible associates, as antimony, lead, etc.; such imperfectly decomposed ore should be cast away and the work repeated on another sample.

Figure 37.



Those who would study and practise exact economical fluxing, will find this Ratio Calculator of Figure 37 very efficient. The base line should be divided into 100 (or any number of units taken for the assay), and the perpendicular into 500 units, for the greatest quantity ever required of any flux; so that when the swiveled hypothenuse is moved down (as shown by the dotted lines) to the desired quantity of flux for the whole amount of the assay, then a vertical line from the actual concentrated quantity upon the base line to the hypothenuse, will, when measured on the end scale by a compass or rule, be the number of grains required. Instead of actual measurement — *especial perpendicular and horizontal lines* may be drawn from every unit — so that the eye may pass up from the quantity of ore as shown on the base line, to the hypothenuse, and thence horizontally to the exactly suitable quantity on the vertical scale at the end.

B. Smelting for Impure Copper.—The sample, having been thus ridded of the more volatile sulphur by roasting, still contains the unaltered gangue with the copper, iron, lead, tin, zinc, etc., in oxidized or chloridized state. The next ensuing results to be obtained are, the fusion of this gangue into a molten condition, by finely pulverized borax glass, or common window glass, which then unites with the oxides to form slag, whilst the copper, being reduced by "black flux," is precipitated in a metallic shower to the bottom of the crucible, to form a button of "impure copper."

Take either of the crucibles alluded to, as shown by Figure 36, of as large a size as the muffle will freely receive, and treat the roasted sample in the following manner:

Carefully transfer the whole of the 60 grains of roasted ore into a mortar, and, after adding and intimately mixing therewith, 60 grains of black flux, they must be finely pulverized, and placed in the bottom of the crucible. Upon this mixture put a layer of 120 grains of black flux, then another of 25 grains of common glass, and still another of 15 grains of borax glass; these are again covered by a teaspoonful of common salt; then, after a half-inch cube of charcoal is placed on top, the cover is put on, the crucible carefully laid into the *moderately hot muffle* and *very gently heated* for some ten or fifteen minutes, as the first action would otherwise boil over some of the contents, and cause a loss. This first stage being safely finished, the muffle may be heated to whiteness for some thirty minutes longer, then the assay must be removed from the fire, and after being lightly tapped to settle the metal to the bottom, it should be allowed to become quite cold, when the button may be obtained by breaking the crucible.

This metallic button should neither be crusted with unreduced dark sulphides, nor the surrounding slag show red color—caused by copper—but be dark green and brittle. These are the simple but valuable signs, which should be thoroughly understood.*

C. Refining the Smelted Button.—This process is intended to produce the same effects as the refinage in the Cornish mode; but it is done in a very different manner, with borax alone, which forms a slag with the other more oxidizable base metals; so that if at the *exact moment* when the last one of these has just departed, the button be withdrawn from the muffle, it will yield nearly all the copper from the sample.

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* When the ore is rich in copper, and entirely free from lead, in addition to borax and common glass, about 10 grains of metallic arsenic may be advantageously used for the production of still more fusible slag, and the precipitation of copper.

A small piece of the side of an old crucible, having suitable concavity, and sufficiently stable to retain its position, is placed in the muffle, with its outer side down, and brought to a white heat by being partially covered with a small lump of charcoal.

The cold button is wrapped in a small piece of strong paper, with its weight of borax glass, and by the aid of tongs, or my *self-closing spring forceps,* (seen lying on the left side of the furnace, Figure 27, page 283,) it must be placed in the hollow of this white-hot crucible's side, just where it can be distinctly seen, when the door of the muffle is kept slightly open, so that a current of hot air may pass over the button, to oxidize the objectionable metals, without unduly lowering the temperature.

Shortly after fluidity is obtained, the characteristic wavings of various colors will be seen; then it will have, for a few seconds, a greenish, pearl-like appearance, (but, if the muffle is insufficiently hot, it becomes solid, as copper will only melt at a certain high degree); when a pure button of copper is *too hot,* it assumes a mirror-like, fixed surface, and should, in either case, be immediately withdrawn from the muffle, and slowly cooled by several instantaneous immersions in water.

The sufficiently pure button thus extracted from the slag, will have a distinct *copper-like* brightness, with smooth, rounded surface, and, when hammered or rolled very thin, it must be so soft, malleable and tough, that the periphery of the disk will not in the least degree expose, even when examined by a lens, any cracks or the slightest appearance of fractures. The *weight of button in grains,* multiplied by 10 and divided by 6 (or $\times 5 \div 3$), will give the percentage of copper in the ore.*

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* The worst features in this method are, that, in ordinary muffles, very small crucibles have to be used, with considerable quantities of the fluxes, so that the black flux of the latter, from rapid action, frequently effervesces over the edge of the former, and consequent errors are thereby occasioned.

For these reasons, I have found it much better to use, with the same quantity of the fusible, *slag-forming* fluxes (of common and borax glasses), but half the quantity of the "black *reducing* flux;" and to vary the weight of the sample taken, according to the percentage of copper in the ore, with these constant weights of fluxes:

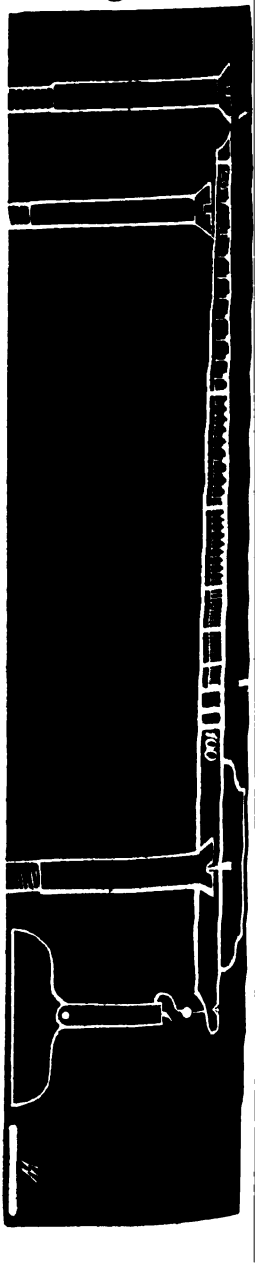
For all ores at about, or under, 25 per cent., take the full 60 grains.
" " " " 50 " " only 30 "
" " " " 75 " " only 20 "

The percentage of metal may then be as readily known ; by multiplying the respective weights of the buttons derived from each by 10 and dividing by 6, by 3, and by 2.

By this percentage of metal change, 100 grains may be as effectually treated for the maximum quantity, etc., as the 60 grains are by the above general manner.

You may also *prepare the sample correctly* and then take only 10 *grains as a round hundred.*

Figure 38.



3. Assaying Copper by the Common "Mouth Blow-pipe."—This is the most easily obtained means for the estimation of the percentage of copper from its ores, for those who have obtained, from long practice, the necessary manipulative skill to produce sufficiently correct results.

It, however, costs about $100 in this country, to provide the necessary tools for the accomplishment of this and the other assays, by the modes of the Swedish metallurgical chemists as described by Professor Plattner and Dr. Sheridan Muspratt, in their large work on "The Qualitative and Quantitative Examination of Minerals, Ores, Furnace Products and Metals, by Blow-pipe," as well as other subsequent authors, who have but repeated these far-fetched elaborations; so that the *poor* amateur has been completely excluded from the little blow-pipe's wonderful advantages, from mere want of funds. To such (who should be studied and respected none the less because struggling with gaunt poverty) I submit the following, so that they may be enabled to arrive at results which will be frequently found sufficiently near for approximate practical purposes.

The cheap tin blow-pipe, with brass nozzle, suggested by Dr. Black, is all that you will be compelled to buy; or, if you prefer it, my "Vest-pocket Blowpipe" of page 212.

A. How to Make a Balance for Weighing the Sample and Calculating its Percentage of Metal.—By cutting a full length strip from the side of a perfectly dry cedarwood cigar box, about hree-eighths of an inch wide, exactly parallel from end to end, nd just the thickness of the wood. Then divide its upper side, ith a compass, as shown on Figure 38, by keeping the one leg lways on the second mark from the right hand, (which is where he knife-edged fulcrum is shown,) and measuring, by transverse otches, the respective distances of each unit of per cent. from 0 down to 20; which are sufficiently high and low for the working percentages of both copper and lead, and as low as can be profitably disposed of, without concentration; then, after still further deepening every tenth notch, it is ready for having a broken *pen-knife blade* inserted for a fulcrum, in the manner shown, as secured in position by the glueing, pasting or pinning down, a short piece of similar wood.

A pan may be now cut from one piece of thin brass, by strong scissors, so as to form both pan and loop, with sufficiently large holes through the sides to receive the small wire hook, the attaching thread being passed up through a small hole made by a pin for its reception, and which is prevented from returning by a small and well-rounded knot; or it may be made just as shown.

Two iron or brass screws are to be next screwed into a board, at suitable distances apart, with their gaffs placed cross-wise; the one must be properly filed to V-shape, so as to receive the knife-edged fulcrum, and the other at exact height for stopping downward travel of the beam; another screw is inserted opposite the pointed long-end of the lever, that must be now balanced by cutting, filing, or scraping away from the pan, which is *intentionally made too heavy* for such final adjustment.

A weight may be now made (which should be about one grain, the quantity suitable for the mouth blow-pipe); this weight may be approximated by cutting off a piece from an ordinary sized pin, five-eighths of an inch long, marked W in the sketch, as exactly one grain is not required.

To weigh out the assay, this must be placed in the groove over the 100 mark on the long end of the lever, (after the lever is correctly balanced to the head of screw, by a short piece of match placed on either side of the fulcrum, just exactly where required for balancing the lever,) the pulverized and very correctly averaged ore being then placed into the scale-pan until the other end returns exactly opposite and points to the top of the screw.

This simple weighing may be still more correctly performed by first *balancing the nominal* 100 *weight in the pan*, with *any suit-able rider* on the *other end of beam*, and then to substitute one after manners of "Wee Pet" and "Little Wonder."

Thus, it will be equal to this weight, and when smelted into metal, although the actual weight of the sample is unknown, its *percentage* of metal can be ascertained, either for this or any other quantity thus taken for assay, when such button is rolled in or out to correctly balance with the *same full* 100 *weight* in the pan.

B. The carefully averaged sample may be first weighed in this manner, and tranferred into either a common sewing-thimble, or empty pistol-cartridge, for more convenient mixture.

C. If the copper ore is a sulphuret, it must be roasted, and in the absence of other tools, it may be very efficiently performed as follows:

Take a piece of thin iron, or a piece of tinned iron plate from a sardine or oyster can, from which burn off *all the tin*, by heating it to redness in a common or sage-brush fire; cut off a square of one inch in diameter, and, by denting a suitably shaped recess in a log of wood, hammer it with the rounded *end* of another small stick of wood into the shape of the large end of a pigeon's egg, when it will, after the extreme corners are turned down for supporting legs, serve for a roasting-cup.

Now take a piece of charcoal—a small branch of one inch and a half in diameter and about four inches long will answer best—and scoop out with your knife from the middle of one end, a concavity to receive the cup, so loosely that the heated air shall freely pass up and around it during roasting, whilst it shall be also kept clear from the bottom by the four sharp angles of the square being bent down upon the top of the charcoal This being done, drill a small hole in the side of the charcoal (with your pen-knife or a sharp piece of hard wood), about a half-inch down from the top, to communicate with the bottom of this roasting-pit, and your furnace is quite ready for kindling. Next place the weight in the notch over the mark 50, and balance the lever by putting sufficient powdered charcoal in the scale-pan, and it will be twice the weight of assay; transfer it to the ore in the cartridge, and mix it thoroughly by shaking it between the finger and thumb, then place it in the roasting-cup, and thence ver the furnace. Light a miner's candle, if you have no blow-ipe lamp; or make a lamp, by placing a rifle cartridge into a ommon broad-based triangular ink-stand, with the flange up-ards in the position of the cork, and drill or pierce a hole therein f three-eighths of an inch diameter, to receive a cotton wick. his, being supplied with olive oil, is now ready for being light-d up for use.

With the piece of charcoal in the left hand, the lamp on a able, and the pipe in the right hand, you may blow the whole f the flame from the candle or lamp into the tunnel, which will, y lighting the fire below and around the roasting-cup, quickly ring it and its contents to a suitably low red heat, which must e thus continued for some ten or fifteen minutes, excepting hort stops for a few seconds for stirring the ore with a small trip of pointed wood, a needle or pin. If it should still smell of sulphur, it must be again roasted with more charcoal, until this odor ceases to be evolved.

D. SMELTING FOR CRUDE COPPER.—Transfer *the whole* of this oxidized ore from the iron dish into the thimble or cartridge, and after adding thereto the same weight of carbonate of soda as was taken of the mineral for assay, it must be intimately mixed, and carefully pulverized, without any loss.

E. Cut off a piece, about one and a half inch square, from strong letter-paper, and plaster the one side with a thin coat of common white soap, to within the eighth of an inch of its edges; it must be made *sufficiently wet*, if *not so already*, for the mixture of the ore and carbonate of soda to stick thereto, as they are lodged in equal manner over the whole surface of the moistened soap. By placing some very small point of something, with the left hand, in the center of the paper, you must now fold each corner inward and down over the center, and then gather the whole into a ball, without extracting any of the mixture of ore and fluxes.

F. Take the same piece of charcoal as just used for roasting (or a similar piece), and cut or saw off the ragged and burnt end; then sink a shaft in the end with your pen-knife, about three-quarters of an inch deep, and sufficiently large that the assay ball may *fall* to the bottom rather freely. Drill a tunnel, of about one-quarter of an inch bore, to this shaft, just immediately over where the fluxed sample lies, and it is ready for smelting, etc.

G. You must now be able to blow in continuously for some ten or fifteen minutes, through the tunnel, the whole mass of flame, at first but gently, until the assay has been well united together in a state of slag, so that no loss may be occasioned, and then in such a manner as to produce the greatest possible heat. The highest heat is not obtained by a strong, but rather a steady and well-directed mild blast; so do not blow too heavily. The shaft may have a few pieces of charcoal thrown in, of about the size of split peas, which will assist the novice, by sustaining the heat for a moment, when he may be unable to keep up continuous blast; or the shaft may be *nearly* covered by a larger piece of coal, so as to increase the reducing effects of the fluxes, etc., on the ore.

It will be seen that the revolution of the assay, as described under "Silver" and "Lead," is prevented by this method, which matters but little for copper; and it has the greater advantage of being an actually enclosed smelting furnace, which, by both retaining and producing heat, as well as being in the very midst of the reducing element of carbon, the copper is much more readily smelted from the more molten mass, which can be rolled from side to side, or otherwise oscillated at the pleasure of the operator.

It is, moreover, much the easier, for the amateur, in the ways of manipulation, fluxation, blowing and smelting; as this close fire and superior reducing flux will obtain copper from its refractory ores, when the open method (as fluxed by carbonate of soda and granulated lead, oxidized off by boracic acid) fails to do so. It will also smelt twice as much.

H. Refining the Coarse Smelted Copper.—The unbroken slag that retains the copper may now be removed from the furnace, and placed just as it is in a small concavity, as previously cut with the point of your knife on the outside of the charcoal, with about its weight of borax glass, and fused by the blue (oxidizing) flame for some three or four minutes, to pass the other more volatile metals away; during this, you should roll the button about in the slag, so as to unite with the larger central button any small globules, which may lie scattered through the slag.

It can be now cast suddenly from the coal into a saucer of water, then taken out, and the copper button examined for purity, as previously described for "Crucible Assay," and either re-treated with borax, or immediately weighed.

The slag may be then re-smelted, if deemed advisable, with additional fluxes, or examined by water treatment, as explained at page 186; so that such copper can be *dried*, and added to the first button.

I. The Percentage of Metal—May be now ascertained by first balancing your calculating lever's pointer to agree with the top of the screw's head; then placing the assay's weight in the pan, and moving the button to balance on one of the units of percentage. You will see that whatever the *weight for assay may have been*, that the button will *balance upon the percentage* with the *same weight as the sample* in the pan.

When the true balance is much above or below any unit, note how far it lies from the pointer, and, after removing to the next unit, you will know tolerably well, by the distance the pointer goes the other way, what intervening fraction of half, quarter or eighth to record.

This calculating lever will, of course, answer for all the other base metal assays; as will the shaft and tunnel mode for their smelting, when otherwise fluxed as directed under their different headings.

The balance lever may be also extended to twice the length of the 20 mark, so as to have a 10, which would be the one-tenth of the hundred; so that a weight could be then made to equal the tenth, and, being put in the pan, a balanced button would represent thousandths instead of hundredths; and, again, another might be made to represent ten-thousandths of a grain, or any other pan weight, for valuation of bullion, etc.

An even beam may be also made to weigh instead of calculate, by having a similar piece of wood, etc., of double the size, and, by dividing the one or both ends into tenths, the weights may be made for the decimal system.

Some years since, I was required to make a gold assay, when beamless and weightless, in far remote and frozen-in winter quarters, where the mother of invention, Necessity, induced me to make an equal-ended lever, somewhat on these principles. The beam was a little over twenty inches long, one and a quarter inch wide, and seven-eighths of an inch thick, and was correctly divided and carefully notched at every inch of the right-hand end, so as to decimate the lever for obtaining either the necessary regular weights or corresponding U-shaped riders.

These tenths were notched, both at right-angles across, and *down the nearer side* of the beam, and the intervening spaces were again severally divided and marked less distinctly across the top of the beam.

The side and vertical notches were then numbered from the center outwards, by three rows of hundreds, tens and units, in the following manner:

100.	200.	300.	400.	500.	600.	700.	800.	900.	1000.
10.	20.	30.	40.	50.	60.	70.	80.	90.	100.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.

The 1000, the 100, and the 10, being over the scale-pan, the range from unity to the thousand is thus completed by the use of riders. The upper side of the wood beam was straight, and the ends were sharpened to a point, which, with the central knife-gudgeon and supports, were all similar to those of Figure 38.

In the center of each end or tenth mark from the gudgeon, holes were pierced by a small needle, and then made conical from the under side, whilst the upper part remained of the same size, so that the thread might more freely oscillate.

After the lever was thus made ready for suspension, I screwed a short piece of plank against the window's side-frame, at a suitable height for cradling the lever in screws, similar to Figure 38, whilst one end of the lever passed sufficiently near the wall for a pointed wire to be driven therein to serve for indicator line in the various balancing and weighing operations. The beam was now greatly reduced by scraping with glass, or a sharp knife, from its under side, more particularly towards the ends; and lastly, balanced (by scraping) to the mark, by changing ends occasionally, and raising or lowering the wall wire, as necessary, to its position of being exactly level with the knife-edged gudgeon, which the corrected lever proved for itself, as it attained more accurate balance.

Scale-pans were now made, by cutting from the side of a square oil-can, two disks of four inches in diameter; and then, after stamping three holes in each, they were threaded and brought to unite with one thread at the top, which was passed up through the lever, and then prevented, by a neatly rounded single knot, from descending beyond the proper position. A platform being next secured to the wall, just under these pans, they were filed and scraped to balance, when the apparatus was ready for use. If it is not sufficiently susceptible to small weights, scrape or scoop out from the *middle* of the under side of the beam until it becomes so.

A "king-post" and its double-triangle stay are important acquisitions to such a beam, as it is made more rigid without interrupting the riders, and its greater upper weight renders less under-scraping necessary for the proper adjustments of the centers of floatation and gravity. It may be made in the following manner:

Saw off a piece from a cigar-box just the width of the beam and three inches long, for a king-post; cut the bottom end to a sharp edge (to suit into the *central* transverse groove of the main lever), and taper the post from the full breadth at the bottom to about three-eighths of an inch at the top, and then cut a neck about three-eighths of an inch down from the top, so as to receive and more securely retain a small wire or piece of strong twine or whip-cord.

Now drive two strong nails into a board, about *an inch and a half further asunder* than the *extreme length* of your *wood beam*, and make a mark exactly midway between them, as an after-guide for twisting the cord or wire.

Take a very small iron or copper wire, (such wire as is used for securing the corks in the bottles containing various effervescing drinks,) or a piece of whip-cord, or strong twine, and, after doubling and tying it at the one end, twist it, by a short, round stick of the size of a pencil, or the "king-post" neck, held exactly over the mid-way line, until the wire hugs it closely, or becomes too tight by shortening, when each of the nails may be withdrawn from the wood, and again driven a quarter of an inch nearer to the center mark, and then, after being again twisted, it will probably be ready for placing in erect position on the lever, which may be done by cutting or sawing a gaff at each end of the beam and placing the loops of wire from the nails therein, in such a way that it shall take good hold, without splitting or fracturing the wood, when the wire is being twisted somewhat tightly, as the "king-post" is sprung into its place.

This post may not happen to be of the exact length to suit the distance of the wire; but, being placed in position, and slightly wedged up by another piece below, the exact additional length will be ascertained, when another can be made to suit. If the points of the beam should be thereby thrown upwards out of line, you may cut the end resting-points a little lower. With perseverance, you can make this balance sufficiently accurate and sensitive for all the practical purposes of assaying.

To Make a Set of Weights—For *such a beam* is a very easy matter, when you proceed as follows:

Borrow from the grocer's store, his one-ounce, or half-ounce or quarter-ounce weight, or a weighed quantity of hard heavy material to equal either of these, or any other weight that you may prefer for the nature of the assay you would wish to make, as that for self-calculation, as described under Heading 4 page 272, under Gold and Silver Assays; or, in fact, any quantity of anything—as a hornful of quartz, of no exact commercial weight—and by placing this in the one pan, you may take a piece of round brass or iron wire, of greater weight, and file it to balance when placed in the other pan, so as to obtain just the weight you desire, and call it your 1000 weight, which must be now bent to U-shape, and have sufficient space between its long legs that it may freely straddle the beam of the scales. It should be also flattened quite thin at the bend of the U, so that it can be more correctly adjusted over the mark.

Now lay this 1000 weight upon the beam to ride exactly over the 100 mark, and take a much smaller wire for a second weight, which make of the same shape as the first, and so diminish it by filing, grinding or scraping, that when placed in the opposite pan, it shall exactly balance the 1000 weight on the 100 mark. Now, by laying this second weight over its mark of 100, and again filing, scraping, or cutting another much smaller piece of ire, cord, or thread, to balance in similar manner, you will ave a 10 weight.

Thus, you have decimalized the large quantity called 1000, and rovided yourself with means to weigh any and all quantities, by hese three weights, from the thousand down to its ten-thouandths part, which I will endeavor to make more intelligible by xplanation of the principle of its action, with examples.

The 1000 weight is always used in one pan to weigh the assay in the other, which, being fluxed, smelted and cupelled, for gold or silver, the clean button is then placed in the left-hand pan, and weighed by the use of movable riders, instead of the usual fixed positioned pan-weights, as follows:

Now we will first suppose it to be a base metal assay, for per thousandths or percentage, and proceed as follows: The button is placed in the left-hand scale pan, and the 1000 rider on the other end of the lever, on the *side*-mark, where you think it will balance (say 600); but it is not so heavy, and this rider is tried on the 500, where the button is still too light to balance therewith, and the rider is again moved to the 400; the button is now found to be heavier than this, *as it always should be for this mode,* when this 1000 is allowed to remain exactly on the 400 mark; the 100 rider-weight is next tried from end inwards, in similar manner, until it also lies exactly over a line, when the button is heavier than the riders (as say at 70 in its own, the second line); now the third, or 10, must be moved inwards, until it does exactly balance—*differing from the other weights, which must keep over the lines*—for this weight has the sole privilege of settling the *small and final* balance, by traversing the whole length of the beam; which, in this instance, shall be over the second mark outside of the 1, in its own third line.

The per thousandths of such a button will therefore be 471.2, and the percentage 47.12; and the value of the bullion or ore may be obtained by multiplying each and every unit of this thousand by 37.7 for silver, or by 602.73 for gold.

As another example, a gold assay made from this 1000 weight may balance its button when the weight 10 is on the first top-notch from the center of the beam, on the *one-hundredth* of the half-beam's length, which would be the tenth of the *unit* of one-thousandth, or a decimal .1, which, being multiplied by the gold multiplier of 602.73, would be equal to $60.27, a quantity still too high for the gold assay of low-grade rock; so that, for suc a purpose, a fourth weight, marked 1, would have to be use and, when put in the position the 10 weight just occupied, would represent the *one-hundredth* of the unit of *one thousand*, the decimal .01, which, being multiplied by 602.73, will equ $6.02 per ton of 2000 pounds. (See Headings 3 and 4 of Chap VII, for general principles for calculation of gold and silver ton, at pages 270 and 272.)

It will be seen, from the above remarks, that the third weight 10, should be used as the smallest weight for silver says, whilst the fourth is necessary for gold; and whichever be used, *the smallest* of the three or four weights will have solitary privilege of ranging the whole length of the beam, the smallest *final* decimation of the weight of the button.

You may take the 100 weight for the silver assay, as your or half-ton, and simply decimate in the lower series, or mak self-calculating one of suitable size for scorification.

In general weighings of ordinary milling and smelting ores is plain that one or more of these weights will record the or, if the self-calculating mode is used, its value in dollars ton, etc., (as fully described at page 272, under Heading 4).

Having made these weights, the self-calculating "assay weights may be even more promptly made by putting the in proper position upon the beam for any one of such quantiti and balancing either by the ore itself, or with an especially ma weight placed in the opposing pan.

If carefully made, this beam and such weights are sufficien exact for all practical working purposes.

The one alluded to weighed as close to the truth as most ex-pensive balances will do, and I was somewhat suprised to find th the buttons, when checked some months after, by a finely finish balance, were found sufficiently near for even commercial purposes. A full and actually correct set of weights may be ma for this or any other beam, if preferred, as all you have to do to make them in a more direct manner as follows: Careful balance the lever, and then with the first small weight in th one pan, weigh an *equal quantity* of a suitable substance in th other, when the sum of both will serve for making weight again, this 2 and 1 will make the weight 3; and the 3 with the and 1, will make a 6; and so on for the rest of the larger ar series, being mindful to always keep to the one pan in ng the weights and in weighing the sample and button, so errors may not arise from unequal lengths of the ends of ever.

eights may be thus corrected to agree with each other, by nencing with the smallest, and carefully ranging upwards by aggregations.

r the way, few sets of weights purchased at high prices will this test, when rigidly made on a delicate balance.

lessen their weight in a safe manner, you must have perse- nce; and the best way that I have found is that of patiently ding them, on a perfectly dry, slowly fretting stone, and suring the loss, by counting the number or length, of equally sed rubs thereon. There is little difficulty in making very progress; but, to become more rapid, and at the same time ciently exact, is quite a business in itself.

cases where you cannot borrow or obtain a *starting weight*, may cut off a piece of an ordinary domestic pin, as five-eighths will be about a Troy grain.

ASSAYING OF COPPER BY MACHINE.—If the sample is a sul- ret, it must be first well roasted in a small crucible, either ed transversely in the cupola furnace, (as shown at page 326, ure 32,) or vertically within the furnace, and fixed with small es of charcoal jammed under and around the crucible, the ting fire being then kindled and regulated by the flames from four lamps, as blown before the blow-pipes.

Balance the main lever to the line on the cross-lever, by ght A; then, after carefully removing A, place weight B in one of the scale-scoop, and sufficient of the intimately mixed and verized ore, in the other end, to bring the main beam to bal- e against the line on the cross-lever, when you may transfer ore to the crucible, for being roasted at a red heat with twice weight of charcoal powder, during continual stirring for ten fifteen minutes, until no sulphurous smell is evolved; being eful to so regulate the heat that the sample shall not aggluti- e.

31. Prepare charcoal, flux and paper, as described under

D, E and F, at page 381, for common blow-pipe, but of twice the length and diameter; and, after taking off the rings in the front of the machine, hold the charcoal in the left hand, and proceed with the smelting of the assay as there directed.

B 2. Take a piece of strong letter-paper, two inches square, which moisten with water, and plaster it over with soap to about one-fourth the weight of sample; next sprinkle the ore over this wet soap, and after adding the same weight of carbonate of soda as the ore, roll all together into a roundish ball.

C. Smelt this fluxed ball of ore for ten minutes, on one of the charcoal or composition supports, closely covered down by another piece of suspended charcoal, (as shown by the spring-fingers of Figure 21, page 172,) taking great care that all the yellow flames shall concentrate upon and steadily cover the sample, with their full reducing influence during the whole time. Care should be taken to avoid any excess of blast, by blowing more gently under a lower pressure of water in the column.

D. Remove this thoroughly fused mass from the coal, and carefully pulverize it in the mortar, without losing any of the metal or slag.

E. Plaster another similar paper with soap, and sprinkle this powdered slag and the flattened disks of metallic copper thereon; substituting for carbonate of soda half the quantity of borax; then fold and smelt as before for eight minutes, after the mass becomes molten.

F. Pulverize the assay carefully by a few blows with a hammer, between cloth or paper, and balance the one or more buttons for per thousandths, on the calculating lever, using one of the weights marked X 4, or X 3; and, for percentage, by taking off or decimating one figure from the right-hand side of such thousandths.

If the copper is not sufficiently fine, re-smelt with its weight of borax for some four minutes.

Minute quantities of copper may be collected from slag much easier after pulverization, by concentration in water, as described page 186. This should be always resorted to as the best eans for ascertaining if more metal may be lying concealed in e slag.

5. **Assaying of Copper by Water Concentration, from the atural Constitutional Ratio, or Metallic Percentage of the articular Kind of Dried Residue.**—Most of the large and lasting copper mines produce somewhat of a general average of disinctive kinds or constitutions of ores, which by having certain quivalent percentages, can be very closely calculated for metal rom the proportions their dried residues bear to the total weight f the whole samples taken; or by comparing, with table of notes made, the one time with another, against corresponding fire assays; as previously alluded to under the water assays of lead and antimony, from the same mine.

A. **Yellow Sulphuret of Copper**—Can be most readily assayed in this way, when concentrated with water, as described in Chapter III, page 163, etc., and dried as directed at page 364.

The weight of metallic copper is then ascertained by multiplying this weight of ore by the decimals .346 for actual quantity, or dividing by 3 for the crucible result.

B. Treat as by "A" for weight of sulphuret, and multiply by your own tabular number, as found by records from previous crucible or humid assays, made for commercial purposes.

C. **The Bell Metal Yellow and Gray Sulphurets of Copper**—May be treated by water, dried and weighed for percentage of such; but, as they are more subject to variations by accidental ingredients, as well as difference of constitution, the multiplier for the local kind of ore found in each mine, vein, or parts of the veins, should be always used for practical working purposes, as previously ascertained by crucible or humid assays.

D. **The Green Carbonate of Copper**—May be very carefully concentrated by water, then dried, and multiplied by .72 for percentage of oxide of copper, and by .575 for metal.

E. **The Blue Carbonate of Copper**—May be treated as under

"D," and multiplied by .69 for oxide of copper, or by .551 for metal.

F. The Red Oxide of Copper—May be computed for metallic copper by multiplying its weight by .888.

G. The Black Oxide of Copper—Is somewhat rare, and being formed in *irregular nests* in the shallow sections of veins, from decomposition of other ores, can be seldom valued by this means.

The last two ores of copper—the red and black oxides—will not stand much water-washing; and the results cannot be relied on, even when compared with tabulated crucible assays.*

The easiest and best means for obtaining your multiplier for such assays is by also making water assays of samples when assaying by crucible, so as to obtain corresponding decimal multipliers as governed by the weight of the button of copper; thus, if an assay from 100 grains of carbonate ore by crucible realized 55.1 of metal, you will, by dividing the 55.1 by 100, obtain .551 for the multiplier; and this rule will apply for *all quantities* in the same manner; for if 100, or any other number of grains, is taken for the assay, and, after concentration, it is reduced to say 15 grains of pure mineral, and that this, or another similar *quantity* and *quality*, is also taken, so as to be assayed by crucible, which may be supposed to yield 12 grains of pure copper; now 12, divided by 15, will, of course, provide the multiplier for this constitutional quality of mineral. Thus 12, divided by 15, will be equal to .8, and the concentrated weight of 15, of the mineral, multiplied by .8, will equal 12, of metal, and serve for future practical approximations.

6. The Humid Assay of Copper.—It is sometimes more convenient, and always more economical, to assay copper by acid

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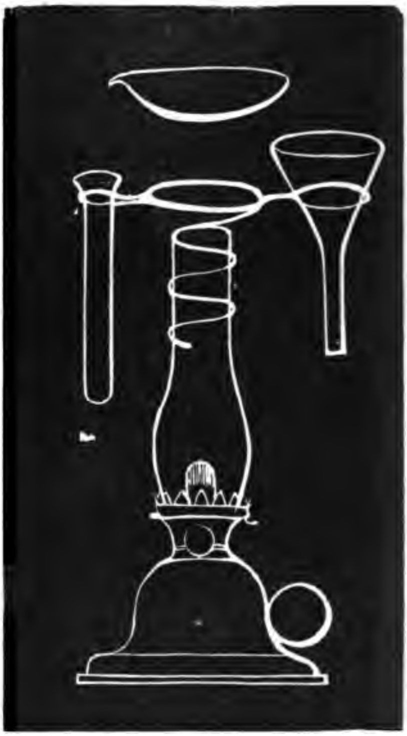
* *For such dry samples*, and even *for all others*, the following means may be resorted to for closely approximating to the quantity of metal that can be obtained from an *unsized* or regular ore, when invariably sifted through a sieve of similar fineness:

Make notes of the percentage of metal realized from *your particular ores*, as assayed by crucible, from time to time, which tabulate in one column; whilst, at the same time, you weigh a measured quantity, and table this corresponding weight in an adjoining column, where the one may be then known from the other, on future occasions.

A common deep yeast-powder box is well suited for this purpose, which may be first balanced, and the quantity then measured and struck off by a straight-edge; the weight being kept for future comparative reference.

process than by crucible; and as it also happens to be within the the reach of the careful amateur, (although he may know but little of chemistry,) I have endeavored, by first oxidizing the sulphurous ores by the comprehensive chemical action of fire, and then adopting that most simple and effective means known as the "Swedish method," to make it not only most efficient for the various constitutions of ores, but very serviceable for all purposes, and within the ready means of every person, by extemporization of the following apparatus for its accomplishment.

Figure 39.



A. Weigh a carefully averaged sample of say fifty grains of the finely pulverized and intimately mixed dried ore, which roast as under the German assay, if necessary, and then place it in a thin porcelain dish, like that seen over the naphtha lamp, (Figure 39,) or in a saucer or cup; now just cover this with hydro-chloric (muriatic) acid, and then place it over the chimney of the lamp on the central loop of the wire as twisted around and over its glass chimney, and carefully evaporate, *almost to dryness*, during continual stirring.

B. From twenty to thirty drops of strong sulphuric acid must be now added, when it should be again boiled until strong fumes of this acid begin to arise, when the vessel must be supplied with water to about six times the volume of the sample, and kept in a moderately warm position for about an hour, until all the sulphate of copper has been dissolved into the solution.

C. Filter this into a basin, through the regular filtering sheet and funnel (as shown by Figure 39), or through blotting paper and a bottle made as a substitute for a funnel, in the manner described at page 327, (not forgetting the sand, which prevents a hole being knocked through when the piece of glass falls before the blow from the hammer,) and finally wash the filter through with clean water until it ceases to have an acid taste.*

D. Place a piece of clean zinc into this basin, which will be preferred by the acid and dissolved, whilst the thus released copper will be simultaneously precipitated from the solution, until the latter entirely loses its greenish-blue color; or this may be known by dipping a clean and bright iron nail therein; for, if the slightest trace remain, the iron will become coated with metallic copper.

E. The undissolved zinc must be now taken out, and all of the adhering copper washed back into the liquor.

F. The solution should be immediately poured away, the copper be well washed with clean water, and slowly dried over the sauce-pan, (as shown by Figure 35, at page 364,) or, with greater speed and risk, over the lamp (Figure 39), by judgment of heat, as regulated by touch and side-screw.

G. Multiply the weight in grains of this perfectly dry copper (as thus obtained from 50) by 2, for its percentage of copper.

H. This may be snugly folded into a paper ball and smelted in a white-hot crucible, with its weight of borax, for about ten minutes, if a perfectly pure button of copper is desired.

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* Filters may be folded in three ways, to suit the funnel.

1. Fold the circular filter across its diameter to a half-circle, and then refold to a quarter circle; take three thicknesses of the paper between the finger and thumb of the right hand, and one thickness in the left; open out to shape, drop into the funnel, wet with water: and it is ready for use.

2. Fold into half and quarter, as before; then again to the eighth of the circle; and, when opened out to shape, with the three thicknesses of paper opposite each other, it may be dropped into the funnel, and wetted as before.

3. *By rule of thumb.* Lay the unformed filter over the funnel; press the center down with the flat part of the left thumb, and then flatten the corrugated sides, with the fingers of the right hand, to suit the funnel. Water as before, and it is ready for use.

I. Twenty grains may be thus treated in the wet way, and the copper smelted into a button with borax, before the machine, where a furnace is not obtainable.

This method, *thus finished* by either means, is more easily and satisfactorily accomplished than by fire alone.

The residue of ore, lying above the filter, should be examined, for better proof that the acids have completely extracted all the copper from the quartz or other gangue.

TICKETING FOR COPPER.—*The smelters and buyers demand that all copper ores shall be crushed to the size of coffee berries, and then mixed into round piles for sampling and assaying by their regular agents.*

The assays are made by units and eighths per cent., which result of percentage is called the "Produce."

The price is governed by the nominal "Standard" of the day, and this is continually varying, to meet the requirements of the market.

The water-weight being first ascertained by drying at 212°, *the value may be readily found by multiplying this "Standard" of the day by your "Produce" or percentage of metal, and dividing by* 100. *This, less the returning charges of say* £2, 10s. 0d. *will be the price per English ton.*

The Cornish copper ores are sampled at the mines on regular days, then assayed and, a few days after, sold at advertised meetings of the buyers' agents at certain hotels in the towns of each district, where folded paper tickets are hand delivered by the different agents, when bidding for the several lots.

Hence these and all similar meetings are called "Ticketings."

The copper-smelting establishments are in Wales, and they are supplied with ores by ships from all parts of the world.

CHAPTER XII.

ASSAYING OF TIN.

1. **By Water and Acid.**—Tin is invariably obtained from its oxide, which has the several remarkable properties of great hardness and high specific gravity; peculiar compactness and cohesion of its disintegrated fragments; offering remarkable resistance both to pestle and to currents of water; never found chemically combined in constitutional mixtures with *other* minerals; it is unaffected by a red heat; and is completely insoluble both in acids and ammonia.

There is one refractory interloping mineral occasionally found mechanically associated with tin, which sometimes deceives the tin miner who relies implicitly on concentration by water, subsequent roasting, bruising, and ridding it from all gangue by re-washing away with water the impalpable oxide of iron, etc., thus produced; it is wolfram, (or the tungstate of iron,) that by its superior weight, and resistance both to *fire and pestle*, still keeps company with tin-stone, which it so closely resembles in many other general characteristics; but it fortunately happens that this wolfram is *partially soluble in acids;* leaving its residue of tungstic acid, that also unites in solution with ammonia.

A. Keeping the above facts in continual remembrance, concentrate 100 grains in the manner fully described at page 164, in Chapter III, on the "Qualitative Discrimination of Minerals by Water Concentrations."

Roast this concentrated sample, at a red heat, for a half-hour with occasional stirring; then pulverize to a fine state of division and wash away the ordinary oxidized iron with further concentration by water, until nothing but the oxide of tin, which thoroughly resists this wash, remains.

If wolfram is absent, it may be dried and weighed for value.

B. If wolfram is present, (and strange ores must be always tested,) the roasted sample should be transferred to a suitable porcelain vessel, and about twice its volume of "aqua regia" added thereto, (which is a mixture of say three parts of hydrochloric—muriatic—acid with one part of nitric acid,) and boiled for a half-hour over the wired lamp (as shown by Figure 39, page 393). After it becomes cold, it must be well washed with water, until the *escaping water* ceases to afford any *acid taste.*

All have now passed away in water and acid solutions, save the oxide of tin and the still insoluble residue of tungstic acid, which resulted from the decomposition of the tungstate of iron, and this must be now removed by addition of a little ammonia, aided by slight warmth and occasional stirring, for about an hour, when it may be again washed and concentrated by water, to remove all adhesion of foreign matter.

It is always advisable to take advantage of the roasting and the subsequent insolubility of the oxide of tin in these solvents, whether this "wolfram" is present or not, for they also serve to remove the last adhering traces of other impurities.

This water assay, when intelligently performed, is absolutely correct.

The heavy, insoluble, water-resisting residue of oxide of tin, being thus washed perfectly clean from the solvent, silica, etc., may be dried as directed at page 364 (Figure 35); or over a suitably wired lamp (similar to Figure 39, page 393), and weighed. The weight *in grains* will be the percentage of this oxide, which is commercially known as "black tin;" and this, being multiplied by the decimals .7838, will give the actual percentage of metal, or "white tin."

If the sample is first roasted, and the assay is thus completed by water-washing, acids and ammonia, no better or safer means can be used for the estimation of tin ore.

If you desire to have an actual metallic button, this concentrated oxide may be reduced by smelting with fluxes, by either of the following methods of crucible, machine, or common blow-pipe.

2. ASSAYING OF TIN BY CRUCIBLE.—In assaying tin by any of the fire methods, it must be also remembered that silica (or quartz) interferes so very much with the effectual performance of

the assay, by strong affinity, that accuracy cannot be even approached, when they are both present; so that it is not only better to first concentrate a large quantity by water and acid, but it is an *absolute necessity* to do so, when anything like truth is desirable. To more fully impress this on the reader's mind, I may state that if an assay be made from a sample of 100 grains of ore, composed of 80 grains of tin oxide and but 20 grains of quartz, under the superior reducing powers of black flux, in consequence of this quantity of quartz being present, only *eighty per cent. of the quantity of metallic tin will be realized;* and, if the sample contained 20 grains of tin and 80 grains of quartz, *no button of metallic tin would be obtained.*

The most consistent way is therefore to first remove all these deleterious portions from the sample, as described under Heading B, on *page* 397, *and then to obtain the button by one of the following modes for fluxed smelting, the best being those first named.*

A. Intimately mix this concentrated pure oxide of tin with its weight of an *equal mixture* of cyanide of potassium and carbonate of soda, (say 14 grains of oxide of tin, 7 grains of cyanide and 7 grains of the carbonate;) transfer them in a scoop to a red-hot crucible, raise the heat to whiteness as quickly as possible, and after the mass has become perfectly fluid, which it will be in about ten minutes, it must be removed; the button may be extracted as soon as it is cold, by breaking the crucible; and then cleaned from slag and weighed.

B. First concentrate to the pure oxide of tin, as under Heading B, page 397, and place this dried residue, without any flux, in a plumbago crucible (or a clay crucible, lined with powdered graphite, or charcoal, will answer the same purpose), and closely shut down the cover (or the broken bottom of another crucible) with tenacious fire-clay, in an air-tight manner. The crucible being carefully removed to the fire, is gradually heated to redness, and the temperature raised to whiteness as quickly as possible, when it may again be carefully removed from the fire, without starting the luted lid.

When quite cold, the button of tin may be removed as before, unless the metal is scattered into several globules, when they should be collected in the manner described at page 364, by pulverization, water treatment, drying, etc.

C. Take the pure oxide, after treatment by roasting, water, acid, and ammonia concentration as under Heading B, page 397; and then add to this sample three-fourths of its weight of carbonate of soda, one-fourth its weight of cream of tartar, (which is also called argol or tartar,) and about one-tenth of its weight of lime. Select a crucible that will hold about thrice this quantity, and, after these are intimately mixed, they must be placed therein and covered first by a thin layer of carbonate of soda, and lastly by a teaspoonful of borax glass, or common window glass. Transfer the crucible to the fire, and warm it very slowly to a low red heat, then after keeping it at this degree for some fifteen minutes, it should be increased to bright red; when, just as soon as the sample is in a proper molten condition, it may be withdrawn and simultaneously swayed by a quick circular motion, so as to wash the many globules from the side of the vessel, and then precipitate them to the bottom by a gentle downward tap of the crucible upon the hearth, into the one button; which, when cold, may be extracted, by breaking the crucible, etc.

D. The ordinary Cornish mode, *for similar reasons to that of the copper assay*, is conducted somewhat as follows: Two ounces of the water-concentrated ore, after being mixed with a half-ounce of "culm," (a kind of anthracite coal,) is transferred to a red-hot crucible, which is increased to white heat, and, when the contents fuse stubbornly, a little fluor spar is sometimes added thereto. In about twenty minutes, the crucible is withdrawn, and its contents then poured into a small iron mould. When cold, the whole mass is pulverized in a mortar, and after the metal has been concentrated by water on a concaved shovel, it is gently dried over the fire, and weighed.

E. The slags from smelting furnaces, which contain a small percentage of tin, associated with silica and tungstic acid, cannot be *actually* assayed by fire; but they may be smelted with iron, which has a still stronger affinity for silica, and consequently, the tin being thus displaced from the slag, is then reduced to a metallic alloy with some of the iron, which can be then more easily analyzed by the humid method, as described under the fifth heading.

3. **Assaying of Tin by the "Wee Pet" Machine.**—Weig for bullion and lead assay by weight B; concentrate as un Heading B, page 397, recommended for crucible assay, then treat with cyanide of potassium and carbonate of soda for the assay of both lead and antimony, under sub-heading at page 362.

4. **Assaying of Tin by Common Blow-pipe.**—The oxide c cannot be treated with any great degree of accuracy before blow-pipe; but the following methods are perhaps more exa than any others, and are at least substantial collateral proofs the residue produced by the system of humid solution and c centration, fully explained at page 397, is really tin.

A. Take one grain of the supposed pure oxide of tin, treat it in the covered shaft-furnace, as heated through the b tunnel, in the same manner as the copper assay described page 381, under Headings F and G, but with these differen that one grain of cyanide of potassium must be added to the flu there named, and that it is directly smelted in the one operati which should be completed in from eight to ten minutes.

B. Take one grain of the pure oxide, which treat in exactly t same manner as directed under the third heading, or sub-hea ing B, page 363, for assay of both lead and antimony, whe alloyed condition.

C. Treat in the manner described at the foot of page 2 under "Tin Assay."

5. **The Humid Assay of Tin and Iron Alloys, as Prepared Fluxed Fusion in Crucible, under Sub-heading E, at Page 3 the Buttons being Especially Obtained for this Purpose fr the Silicious and Tungstic Slags of Smelting Furnaces.**—As so miners may, in far remote regions, have to smelt their tin o into metals, it is imperatively necessary that they should hav means for estimation of the amount of tin that remains unreduc in their slags. Although the crucible greatly facilitates the h mid assay in this instance, by causing iron to replace the tin the slag, and forming a simple alloy of metallic iron and ti it will not thoroughly accomplish the assay; therefore, as this bu ton of alloy must be treated by some humid process, I sugge

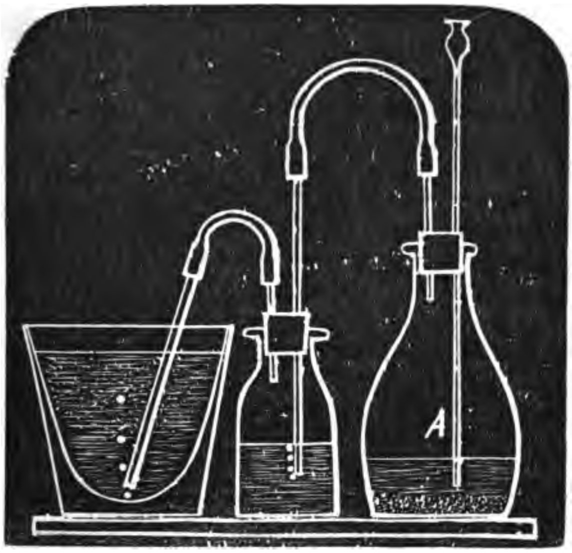
the following as being thoroughly reliable, and yet comparatively easy to accomplish, in such fixed establishments.

This button of alloy, as obtained from the slag by fusion, process E, page 399, must be brushed thoroughly clean, then dissolved in a boiling mixture of strong hydro-chloric (muriatic) acid, three parts to one part of water, and filtered into an open-mouthed vessel, as a glass tumbler or basin.*

The tin must be precipitated in the following manner, by sulphide of hydrogen gas, which may be made expressly for the purpose, in the apparatus illustrated by Figure 40.

This view explains itself, as to general arrangement of parts. The tubes may either be made of glass, or glass and india-rubber combined, or of quarter-inch rubber tubes alone. It may be also ordered as "sulphide of hydrogen apparatus," and supplied in proper condition for immediate use.

Figure 40.



The bottle, A, being placed on a suitable board, is supplied with about an ounce of sulphuret of iron and the small bottle half filled with water; then, after the corks are drilled and tubed as shown, they are moistened and inserted, in an air-tight manner, into the necks of the bottles, with the last bent tube discharging near the bottom of a glass tumbler containing the solution, just as shown. The bed-plate or tray that sustains the vessels is now moved out-doors, or to a chimney, (as this gas is very disagreeable and poisonous,) and the bottle, A, is first supplied, by way of the long funnel tube, with sufficient water to cover the sulphide of iron, and then with concentrated sulphuric acid; the sulphide of hydrogen gas thus formed, being prevented, by the liquid which rises in the tube, from direct escape, is first passed into the small bottle, through its water, and cleansed from any mechanical substance before entering the solution, where it precipitates the tin to a yellowish-brown sulphide, which darkens on exposure to the air. The gas should be passed through until the solution very strongly stinks thereof when moved from the supply pipe.

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* *Before the solution is filtered,* it may be tested for copper, by a piece of bright metallic iron, which should also *precipitate* all of this metal from the solution, when the *iron of the alloy* was insufficient for *this effect.*

It may then be carefully poured off from the precipitated sulphide of tin, and, after the latter has been well washed by water, it should be very gently roasted in a smooth French crucible, at low red heat, until all sulphurous odor ceases; then the cold contents may be either re-heated with a little carbonate of ammonia, and, when cold, weighed as oxide and then multiplied by the decimals .7838 for metallic tin, or it can be actually reduced to metallic tin, by fusion with carbonate of soda and cyanide of potassium, under either of the most convenient fire methods.

Tin is commercially known by its two names of "white tin" (or metal) and "black tin" (or its oxide).

Tin is smelted in the several districts of Cornwall, where it is extensively mined, and for which the miner has two markets.

The large smelters require the ore, when finely crushed and entirely freed from all other gangue, to be delivered at their works as pure "black tin," when they honorably give just what they think the fair price under that day's quotation of the price of "white tin."

The smaller buyers go to young mines and purchase the tin stone by "ticket," then after crushing it in their private battery, they concentrate it to purity and sell this as "black tin" to the large smelting blishments.

The American people entertain much higher notions about the values of tin mines, than they should; for the best vein in Cornwall could not be made profitable here, because this ore requires very much of the *especially educated cheap labor* of that region before it can be rendered marketable.

This is almost entirely performed by small girls and boys, at wages ranging from twopence to sixpence per day. The boys then go to work "underground," and the girls continue improving until they get, when thoroughly skilled, only one shilling (or about a quarter dollar) per day.

The general average from these tin mines is invariably low, so that very large quantities have to be pulverized, to a size even smaller than that for the extraction of gold from auriferous quartz, by large and heavy batteries driven by water or steam power.

The wet pulp is then first received into flumes for partial concentration, and then passed through many ingeniously contrived and much more perfect concentrators, by the cheap skilled labor alluded to above, and processes as more fully described in the Second Volume on Mining and Metallurgy.

Notwithstanding all these advantages, there is only one tin mine in that country yielding profits at this present time.

If, however, this ore should be found in very large quantity, of unusually high percentage, in a concentrated alluvial deposit near a shipping point, it might be then profitably forwarded, *in the stone*, for final Cornish treatment and sale.

CHAPTER XIII.

ASSAYING OF MERCURY.

There are many ways by which mercury can be assayed, both by fire and humid methods; and three of such modes may be more particularly commended to prospectors and miners, for practical purposes.

1. ASSAYING MERCURY BY CRUCIBLE OR SCORIFIER.—Nearly all the mercury of commerce is derived from cinnabar, and it is generally found tolerably free from other volatile substances; so that it may be estimated sufficiently near for practical purposes, by first thoroughly drying at 212° and *roasting* say 100 grains of unfluxed ore in a suitable vessel, (as a scorifier, roasting-cup, platinum or smooth French clay crucible,) *at a red heat*, for about ten minutes, when the *difference* of the weights of the *vessel, before and after roasting*—as both sulphur and mercury are thus volatilized—will equal the weight of the cinnabar.

This loss of weight, multiplied by the decimals .8621, will give the theoretical quantity of metallic mercury; and, by obtaining your *working multiplier*, the quantity that can be obtained in practice.

2. ASSAYING MERCURY BY RETORTING THE FLUXED SAMPLE.—Mercury, and all of its constitutional combinations, can be assayed, by being heated to redness with the following fluxes, in a closely covered and very small iron retort, similar to those used by amalgamators, when working with miniature test pans.

A. To every 100 parts (in weight) of the sample of ore, add the *quantity stated* of *one* of the following substances: iron or copper filings, 30 parts; or of black flux, 60 parts; or an equal mixture of powdered charcoal and lime, 70 parts; these must first be very intimately mixed together, and then covered with an additional layer of similar flux.

Gradually heat up to low red, then to red, for some ten minutes, until mercury ceases to come through the discharge pipe of the retort; and, after lightly tapping this pipe to cause the many loitering globules of adhering mercury to pass out and down into the condensing water-trough, you may weigh this mercury for percentage.

B. Take 100 grains of ore, then flux and mix as above, and place the mixture into a thin florence flask, (as a salad-oil flask,) and warm the bulb to red heat over a charcoal fire for twenty minutes, with its long neck almost horizontal, and kept quite cold by a wet rag, so that all the mercury may deposit in the neck. Remove the rag, and, when the bottle is cold, file the neck all round, just below the mercury, and break it off from the bulb; now slowly dry it at about 180° of heat; and after weighing the mercury and glass, then drive away the former by heat, and reweigh the glass; the difference will be the weight and percentage of mercury.

C. Treat 10 grains of ore in a long test tube, in manner as under the last sub-heading, B, then break, dry, weigh and volatilize, when each tenth grain passed off by this sublimation will be the unit of percentage.

3. Assaying Metallic Mercury by Water-Washing. — First carefully wash 100 grains of the sample in a cupful of clean water, and pour the water away; then repeat this washing twice or thrice, half fill with water, dissolve about ten grains of cyanide of potassium therein, when, after washing the sample with a circular sway in this liquor, it may be warmed, and allowed to remain until cold.

Now concentrate and free the metal from all the lighter gangue, by water-washing over the margin; then gently dry the mercury and weigh in a previously balanced paper pan for percentage. If cinnabar should be present, the difference of this weight and that of either of the assays made under the second heading, by letters A, B and C, will also give the percentage for mercury contained in the ore.

4. **Assaying Metallic Mercury by Preliminary Water Concentration and Final Collection by Direct Amalgamation.**—Well wash and concentrate 1000 grains, as just described under Heading 3, and after discharging the dirty and refilling the vessel with clear water, add the cyanide of potassium so as to chemically clean the globules and increase the affinity of the quicksilver for amalgamation. Now thoroughly brighten a piece of gold, silver or copper, of any size corresponding to the quantity of mercury to be collected, and after accurately weighing it, just drop it into the concentrated submerged residue and agitate the whole by side-swaying of the water; when, after the amalgamation is thus fully effected, you may carefully dry at 212°, and weigh upon a paper pan. The difference *over* the first weight of the unamalgamated bright metal will give the percentage of mercury.*

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* I have frequently found this mode most admirably convenient, and much more accurate than any other, dry or wet, method.

CHAPTER XIV.

ASSAYING OF IRON.

Iron can be estimated by fire, sufficiently near for practical purposes.

1. BY CRUCIBLE.—Here, again, the chemical action may be very much simplified by the preliminary roasting of all its ores into the one most reducible combination, peroxide.

A. Take two samples, of 100 grains each, of the finely pulverized and carefully averaged ore, and roast them within the muffle in scorifiers, at red heat, for at least one hour, or until it has a red earthy appearance, when cold.

B. Take two London, Cornish, or French crucibles, of about five inches high, which line with charcoal, by placing smaller and similar crucibles within, and ramming moistened charcoal between the vessels.

The inner crucibles being then withdrawn, by suitable jostling and twisting motions, the outer crucibles are ready for use after they have been slowly and thoroughly dried.

C. Intimately mix this roasted (100 grains) sample with 100 grains of one of the carbonates of lime, (as chalk, marble or calc spar,) 100 grains of common window-glass that is free from lead, and one part of charcoal, all finely pulverized.

D. Transfer these mixtures to the duplicate charcoal-lined crucibles, and, after filling the remaining spaces with small pieces of charcoal, the lids must be closely luted with fire-clay.

E. Place the crucibles in the furnace, and raise them slowly to a red heat; then increase to *white heat* for full twenty minutes, when they may be withdrawn, and gently tapped on the top of the furnace, to settle the small floating buttons into the one large button at the bottom, which, when quite cold, may be removed and weighed for percentage of iron.

If the buttons are still separated, they may be collected from the pulverized slag by magnet, or by water-washing, drying, etc., as described at page 186.

The metal should not be so brittle as to break into powder under the hammer; but, rather, to flatten slightly in a partially ductile manner, then crack around the edges, and fracture as whitish cast-iron.

2. ASSAYING OF IRON BY WATER CONCENTRATION.—*Some of the more compact and slightly friable iron ores* can be assayed very closely by water concentration and calculation, either from their *constitutional* quantities or previously *tabulated* percentages, from the weights of their dried heavy residues; the most prominent of which are the magnetic iron ores, the carbonate of iron, common iron pyrites, arsenical iron pyrites, and the worthless tungstate of iron.

These can be assayed by carefully concentrating 100 grains of ore, as pulverized and averaged by the method fully described in Chapter I, Section III, and multiplying the weight of the dried residues by either their constitutional or tabulated *practical* percentages, and dividing by 100.

There are others, including all which freely pulverize to a red and impalpable powder, that *cannot be thus assayed* to even an *approximate degree* of accuracy; for the *whole* may be thus passed away in mechanical solution, by continued pulverization, and additions of water.

3. APPROXIMATE ASSAY OF IRON, AS GOVERNED BY VOLUME AND WEIGHT, FROM TABULATED COMPARISONS WITH PERCENTAGES OF PREVIOUSLY MADE FIRE AND HUMID ASSAYS.—*The last-named friable ores which cannot be assayed by water, as well as all other ores, that can be, may be estimated for practical working purposes, on the peculiar or particular ores of the same mine, in the following ever-ready and costless manner:*

Record every assay that you have occasion to make or obtain by fire or acids, in working on the large scale, in its proper place, into one *long column*, having a line for each profitable unit of percentage; and, for *every assay thus actually made,* take one *measure* of the ore, (say a tin yeast-box, or a coverless tin flour-dredge, which has been balanced by a suitable balance-weight kept for the purpose,) by striking it off straight across the top, and record *its weight* in the opposite *corresponding unit* of *another* column, for *future reference;* and in a short time you will have a sufficient series within the required range for percentage.

The ore must, as a matter of necessity, for this and ordinary practice, be passed through the same fine sieve, and it will be found more accurate to settle down the powdered ore by tapping lightly on the sides of the vessel until it will receive no more, than merely filling and striking off without it; but a third column may be added, to show the weight of both results, for even more compact comparisons.

The ore must also be perfectly dry, at all times alike, for the fire, the humid, and measure estimations.

The high percentage of the iron ores, the rare and trifling presence of other metallic minerals, and comparatively great differences of the specific gravities of the ore and gangue, together with the difficulty, uncertainty and expense of making either the humid or fire assay, will render this mode much more exact and valuable for iron than most other assays; and such fire or wet assays may be made by any distant assayer, for your especial and local guidance when repeated by both measure and weight, as required.

Indeed, it would be quite a desideratum for the iron miner, if it did no more than indicate, in this prompt manner, by but one example, the zero of percentage that will not pay for shipment to the distant smelting furnace, or market.

4. THE HUMID ASSAY OF IRON—Is greatly simplified and facilitated by a preliminary roasting of about an hour, at full red heat, which brings (by volatilization) the ores that contain the most refractory elements for humid treatment into the same conditions as the other natural ores, which yield more readily to the action of acids.

The following is, perhaps, under all circumstances, as easy and safe a means as can be employed by the miner, who is neither

well versed in chemical reactions and manipulations
plied with the numerous, complicated, and expensive
that would be otherwise required.

A. Roast 50 grains of averaged, finely pulverized ore in
chalked cup, or crucible; and, after scraping the whole
ore from the roasting cup, it should be again pulverize
gently boiled for a half-hour, with about six times its vol
"aqua regia," in a small glass flask or porcelain dish, pl
the wire ring over the lamp (as shown at page 393, Figur
so regulating the heat that none of the liquid shall be pro
over the vessel by excessive ebullition.

B. Allow it to stand and cool down for a few minutes,
the liquor becomes clear, by the settlement of the solid por
and carefully pour it into some other suitable vessel, that
has a pouring lip; then *treat the solid residue with another* qu
of the acids in the same manner, and unite the two liquors
the one basin.

C. This solution must now be completely evaporated by h
ing; after which, the soluble parts of the dried residue must
again dissolved in about the same quantity of an equal mix
of hydro-chloric acid and water.

D. This is then filtered, and, [illegible] the two insoluble resid
are placed (or, rather, washed) u[illegible] filter, it is well clea
by additional water, to pass the [illegible] of the acid thr
into the solution, so as to obtain a[illegible] before it is put as
[illegible]

E. It may [illegible] thly boiled for [illegible]
[illegible], the iron, w[illegible]
[illegible] precipitated.*
[illegible] from the sesqu
after they have been [illegible] ed with water, by
caustic potash for some [illegible] thin porcelain

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* The warming is not imperatively [illegible]
action by aggregation, facilitate the filtration, [illegible]

mp (as in the first acid stage) which dissolves out the alu-, leaving the oxide of iron, that may be well washed with , and perfectly dried at 212° (over the sauce-pan, as previ- described, if you have no more usual means), then it may nited by a match, to burn off all the surplus weight of paper a clean saucer, and the residue weighed.

is weight, multiplied by .7, will be just that of metallic iron, as 50 grains were taken, this being multiplied by 2, will give percentage from your sample.

. If it be desirable to ascertain the percentage of the insol- portion of silica, etc., twice the weight thereof will also show fter the first filter has been *thoroughly dried*, and its weight oved therefrom by complete ignition.

. The lime and magnesia can be also known (to provide for re exact fluxing), by first adding to the original ammoniacal ation, from whence the iron was precipitated, sal-ammoniac, loride of ammonia,) which prevents magnesia from being pre- itated; and then adding oxalate of ammonia, to precipitate the e as oxalate of lime, which may be changed to carbonate of e, as found in the rock, and used for flux, by warming to a l heat, with a little slightly moistened carbonate of ammonia; en it may be weighed as such, and multiplied by 2, for per- ntage.

The magnesia can be now precipitated from the solution ition of phosph[illegible] soda, which deposit being filtered, ried, ignited [illegible] to burn off the weight of paper), [illegible] may be [illegible] approximated for magnesia by [illegible] weight [illegible] mal .36, etc.

[illegible] state, as dissolved in water, [illegible] pure filters when passing [illegible] well versed in chemical reactions and manipulations nor supplied with the numerous, complicated, and expensive facilities that would be otherwise required.

A. Roast 50 grains of averaged, finely pulverized ore in a well chalked cup, or crucible; and, after scraping the whole of the ore from the roasting cup, it should be again pulverized and gently boiled for a half-hour, with about six times its volume of "aqua regia," in a small glass flask or porcelain dish, placed on the wire ring over the lamp (as shown at page 393, Figure 39), so regulating the heat that none of the liquid shall be projected over the vessel by excessive ebullition.

B. Allow it to stand and cool down for a few minutes, until the liquor becomes clear, by the settlement of the solid portion, and carefully pour it into some other suitable vessel, that also has a pouring lip; then *treat the solid residue with another quantity of the acids in the same manner*, and unite the two liquors into the one basin.

C. This solution must now be completely evaporated by boiling; after which, the soluble parts of the dried residue must be again dissolved in about the same quantity of an equal mixture of hydro-chloric acid and water.

D. This is then filtered, and, after the two insoluble residues are placed (or, rather, washed) upon the filter, it is well cleaned by additional water, to pass the last relics of the acid through into the solution, so as to obtain all the iron, before it is put aside for precipitation.

E. It may now be slightly boiled for five minutes, when, by adding an excess of ammonia, the iron, with the alumina (very often found present) can be precipitated.*

The alumina may be separated from the sesqui-oxide of iron, after they have been first well washed with water, by boiling with caustic potash for some time, within a thin porcelain dish, over he lamp (as in the first acid stage) which dissolves out the alunina, leaving the oxide of iron, that may be well washed with vater, and perfectly dried at 212° (over the sauce-pan, as previusly described, if you have no more usual means), then it may e ignited by a match, to burn off all the surplus weight of paper ver a clean saucer, and the residue weighed.

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* The warming is not imperatively necessary, but will, by lessening the gelatinous action by aggregation, facilitate the filtration, etc.

This weight, multiplied by .7, will be just that of metallic iron, and as 50 grains were taken, this being multiplied by 2, will give the percentage from your sample.

G. If it be desirable to ascertain the percentage of the insoluble portion of silica, etc., twice the weight thereof will also show it, after the first filter has been *thoroughly dried*, and its weight removed therefrom by complete ignition.

H. The lime and magnesia can be also known (to provide for more exact fluxing), by first adding to the original ammoniacal solution, from whence the iron was precipitated, sal-ammoniac, (chloride of ammonia,) which prevents magnesia from being precipitated; and then adding oxalate of ammonia, to precipitate the lime as oxalate of lime, which may be changed to carbonate of lime, as found in the rock, and used for flux, by warming to a red heat, with a little slightly moistened carbonate of ammonia; when it may be weighed as such, and multiplied by 2, for percentage.

I. The magnesia can be now precipitated from the solution by addition of phosphate of soda, which deposit being filtered, washed, dried, ignited (by match to burn off the weight of paper), and weighed, may be closely approximated for magnesia by multiplying this weight by the decimal .36, etc.

These re-agents should be in liquid state, as dissolved in water, and must be filtered through clean and pure filters when passing it into the solution that is being analyzed.

CHAPTER XV.

ASSAYING OF MANGANESE AND ZINC.

1. By Crucible.—The pulverized oxides of manganese may be reduced to metal by being first mixed with oil into a paste or ball, and then subjected, for twenty minutes, to the greatest possible heat by common furnace.

The metal itself is, however, of little value, either for use or ornament, being very infusible, hard and brittle; it is of grayish-white color, tarnishes quickly in air, and is rapidly oxidized when heated. In its mineral condition of peroxide, it is valuable in the laboratory, and various departments of the arts; and for such purposes, the quantity of oxygen that can be extracted therefrom is its best measure for useful value.

2. Estimation of that Portion of Oxygen which is Free for Extraction, from Manganese, by Heating to Redness in the Muffle.

A. Warm 100 grains of the averaged, finely powdered ore, in a scorifier, or roasting-cup, for a half-hour, in a muffle, at a *red heat;* remove it therefrom, and weigh, after it is quite cold, for this heat has caused the removal of *the quarter* of its *real quantity* of oxygen, and one-half of its *disposable quantity* for the production of chlorine gas; and as the pure peroxide of manganese would, when thus treated, release 9.25 *per cent.* of oxygen, it follows that the loss of weight so sustained measures its ratio of value. For example, if this loss should be, say 6 grains; then as 9.5 is to 6, so is 100 to its comparative percentage of value, as compared with the pure oxide; or, 100 multiplied by 6 and divided by 9.5, equals its percentage value of 63.1.

In this mode of assay, you must be certain that no native metals are present, as they would increase the weight by oxidation; or compounds that would undergo changes at red heat;

ll of which are rare in these ores. *This method, however, is at the st, only an approximation.*

B. *A white heat, applied as above, displaces one-half of the oxy-en, which is all that can be realized for the practical purpose of btaining the gases of oxygen or chlorine; but this half is not so readily nd surely accomplished as the quarter, by red heat.*

3. Assaying the Peroxide of Manganese by Water Concentration.—The peroxide of manganese is the only valuable one of these minerals; which is black, or slightly brownish-black, when powdered.

It may be concentrated by water, with trifling loss; and when free from iron, which must be first tested, it is seldom associated to any extent with the other minerals.

It may be concentrated in the manner of lead, antimony, tin, copper, etc., and then dried and weighed for percentage.

The pure peroxide of manganese contains of oxygen 37 per cent., 18.5 of which is, as stated, the useful half, which can be only extracted for practical requirements; so that the concentrated weight being ascertained, the ratio of percentage may be known by calculation, as before.

The multiplier may be made for your own mine, as in the other instances; or a double-column table may be founded from the next following and correct chemical method.

4. The Humid Assay for the Peroxide of Manganese.—The following mode is sufficiently accurate for all the purposes of the metallurgist, and can be performed, with but little difficulty, by an amateur.

A. Thoroughly clean the sulphide of hydrogen apparatus, (shown by Figure 40, at page 401,) and place 100 grains of the manganese ore into flask A; after stopping down the vessels perfectly gas-tight, with the tubed corks, as shown, and nearly filling the receiving tumbler with lime-water, pour down the long funnel of vessel A about 600 grains of hydro-chloric (muriatic) acid upon the ore, and apply gentle warmth, by placing bottle A in a small sauce-pan of cold water, and then warming it over a fire or lamp.

The chlorine gas thus formed will pass over into the second bottle, and thence into the tumbler, (or any other large vessel,) and through the lime-water, and, having strong affinity for the lime, it instantly forms a chloride therewith, from which the quantity of chlorine can be readily ascertained by simple calculation.

It will be necessary to have an excess of lime-water in the precipitating tumbler, and, before finishing the analysis, to drive over all the chlorine gas into the lime-water, by pouring water down the long tube A, so as to first fill this vessel with watered acid, and then to expel the gas from the second vessel, by just sufficient air to force over the thus diluted acid therein, until this bottle also becomes freed from the remaining chlorine gas. The *lower end* of this discharge tube into the second bottle, should be close up under the cork.

Care must be taken that neither the breath nor the diluted hydro-chloric acid shall pass over during this expulsion of chlorine gas, as the former would form carbonate of lime, and the latter an excess of chloride of lime, and spoil the operation by giving an excessive result.

After these precautions, the liquor may be filtered from the tumbler, so as to collect the chloride of lime on the *previously balanced filter*, as either dried at 212°, in a suitable water oven, or in the more ready manner as directed at page 364, over a sauce-pan of boiling water.

The 100 grains of pure oxide of manganese, when thus treated, will release about 75 of chlorine gas from the acid, which, by uniting in this tangible manner with lime, will form 117.2 of the chloride of lime; and, this dried weight being known, the weight or percentage of gas from the ore may also be known in the following manner:

If the weight of the chloride of lime produced from 100 grains of ore was say 58.6, then it would be, as 117.2 is to 75, so is the weight of 58.6 to that of chlorine gas realized from your ore, and its ratio of percentage value for ordinary practical purposes. Or, $\frac{75 \times 58.6}{117.2}=37.5$.

If you take a smaller quantity for the assay, as 50 or 20 grains, first multiply by 2 or by 5, to throw the quantity into hundredths, and still proceed to figure for value as in the preceding paragraph.

ASSAYING OF ZINC.

1. BY WATER CONCENTRATION.—The zinc ores may be approximated for percentage by water treatment in precisely the same manner as the ores of lead, antimony, copper, tin, iron and manganese; and the weight thus obtained, being multiplied by its equivalent, or *practically ascertained* decimal number, will give the percentage of metal; therefore as the fire assay is tedious, uncertain and very difficult, this water mode will be quite serviceable to miners for everyday purposes.

2. HUMID ASSAY OF ZINC ORES.—Dissolve 100 grains (or any more convenient quantity to suit your purpose), in four parts of hydro-chloric (muriatic) acid and one part of nitric acid, by boiling until the solution is evaporated to perfect dryness, and the dish becomes almost red-hot; then moisten with sulphuric or nitric acid (not hydro-chloric), gently warm, until dissolved; add water, and filter into a suitable vessel for precipitation. Add a strongly alkaline *excess* of aqua ammonia and warm, which will precipitate iron, manganese, etc., as well as the zinc; but being *in excess*, it will re-dissolve the manganese and zinc, which must then be again filtered, and the residue washed with a very dilute solution of ammonia, to carry through the whole of the zinc, and, if manganese is present, that also; therefore, unless you have ascertained (as directed in Chapter VII, under that mineral's heading) that it is *not present*, you had better, for greater safety, separate it from zinc, in the following manner, before final precipitation:

Add acetic acid to the solution, until it becomes strongly acid, which keeps the manganese in the solution whilst the zinc is being precipitated therefrom by sulphide of hydrogen gas, (as generated in the apparatus shown by Figure 40, described at page 401,) and forced through this strongly acid solution until all the zinc is precipitated, when this sulphuret of zinc may be collected on a filter by filtration, well washed by water, and then dissolved in dilute hydro-chloric acid.

An excess of carbonate of soda must be now added to this filtered solution, until no more carbonate of zinc is deposited.

Now *dry a clean filter* at 212°, and accurately balance or weigh it on your scales, then fold it into a funnel, filter the solution and well wash the overlying residue, *dry perfectly at* 212°, weigh.

This weight, less that of the dried filter, will be the weight carbonate of zinc; which, being multiplied by the decimal .8, give its percentage of metallic zinc.

There are several fire methods for assaying zinc ores; but, they are neither exact nor of easy execution, I have deeme better to rely on the two humid modes which are given abo rather than recommend and describe much more uncertain less reliable manipulations.

The water treatment will be sufficient for practical purposes the mine, and this chemical mode, when carefully performed, quite certain for its commercial estimation.

The method of volume and weight, previously described, be also used on similar ores of the same vein, for the minimu percentage that will pay for extraction, so as to approximate working purposes, as tabled in corresponding columns as figu from humid assays.

To ascertain the amount of gangue, it may be also roasted about an hour, at a high red heat, and then weighed for lo of weight of ore, and the remaining approximate weight of th non-volatile residue of matrix.

CHAPTER XVI.

ASSAYING OF COAL, AND OTHER FUELS.

1. **By Ignition in a Clay or Platinum Crucible.**—A good ractical estimate of the quality of coals may be made by simple gnition of 100 grains in a muffle, or in any open and clear fire, or a sufficient time to consume the combustible elements, and hen subtracting the residue of unconsumed ash from the original weight taken, for the percentage of inflammable matter.

The character of smoke, duration of flame and coke, with the nature of clinker, etc., being duly noticed for quality, will give additional evidence of superior or inferior kinds, beyond the mere weight of carbonaceous matter present.

2. **Assaying Coal in Crucible, as Governed by Quantity of Carbon Present.**—The most ready means for the estimation of a fuel is that devised by Berthier, a French chemist, which may be performed as follows:*

Great care must be taken to free the litharge from minium, and it is better to purify it by fusing in a clean crucible, at a red heat, an intimate mixture of 3 grains of pulverized charcoal with 1000 grains of the impure litharge, which will extract the minium, and leave the litharge as it should be, when it can be pulverized and used with greater confidence.

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* Dr. Ure, in the supplement to the Dictionary of Arts, Mines, and Manufactures, says: "On subjecting this theory to the touchstone of experiment, I have found it to be entirely fallacious. Having mixed, very intimately, 10 grains of recently calcined charcoal with 1000 parts of litharge, both in fine powder, I placed the mixture in a crucible, which was so carefully covered as to be protected from all fuliginous fumes, and exposed it to distinct ignition.

"No less than 603 grains of lead were obtained; whereas, by Berthier's rule, only 340 or 346.6 were possible. On igniting a mixture of 10 grains of pulverized anthracite, from Merthyr Tydvill, with 500 grains of pure litharge, previously fused and pulverized, I obtained 380 grains of metallic lead. In a second experiment, with the same anthracite and the same litharge, I obtained 450 grains of lead; and, in a third, only 350 grains. It is therefore obvious that this method of Berthier's is altogether nugatory for ascertaining the quantity of carbon in coals, and is worse than useless in judging of the calorific qualities of different kinds of fuel."

Now unadulterated carbon will reduce from litharge 34.5 times its weight of lead; and hydrogen 103.7 times its weight of lead; so that the amount thus reduced by any fuel will give the comparative quality of the fuel.

I have found it much better, for practical purposes, to disregard the above data, and to first take 10 grains of finely pulverized coal, *of known first-class quality*, with 300 grains of litharge, most intimately mixed together and covered by a layer of another 300 grains of litharge; and then to take a second 10 grains of the fuel to be assayed, and next, after being similarly prepared, they must be placed, exactly under the same conditions, just side by side in a furnace, and slowly warmed to redness; the heat is speedily increased to white, then they may be withdrawn from the fire, and allowed to get quite cold before the buttons of lead are extracted by breaking the crucibles.

About 20 grains of common glass powder may be first put in the bottoms of the crucibles, so as to protect the lead from the subsequent action of the litharge, and thereby produce a more compact and clean button.

If the litharge, whether pure or not, is first intimately mixed to a correct average of quality, as instructed for the preparation of an ore assay, in Chapter I, and the coals are both dried, there can be no reason why these assays of genuine coal, and that on trial, should not be an exact comparison for ratio of values; conducted, as they are, by both flux and fire, in a precisely similar manner throughout.

You will find this exactly similar duplicate comparative test with *first-class coal* or *charcoal*, more simple in execution and most reliable, when the litharge has been only used in slight excess after being first mixed into correct average.

John Mitchell says, in his large work on Assaying, that if the commercial white lead is used, instead of the impure litharge, much closer results can be obtained. He has not, however, endorsed Ure's condemnation of Berthier's method.*

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* Here the otherwise useless and too common long-stem tobacco pipe, as made of clay, will be again useful for the purposes of ascertaining the lighting and coking qualities of different coals, as by filling the bowl with pulverized coal and closely luting it with clay, you may, by placing it in a red-hot fire, ignite the gas as it issues from the stem, and readily note the quality and duration of the light, as well as the character and quantity of the coke—if any should still remain—in the bowl.

3. Assaying Coal by Common Blow-pipe, for Approximate esults, when Traveling.

A. Burn off all inflammable ingredients from exactly 1 grain
: the powdered coal, in the manner of roasting a copper assay
.s described at page 380), and weigh the residue of clinker and
sh, for percentage of useless elements; which, being deducted
'om the 1 grain, or the 100 parts, will give the combustible per-
entage. Then, compare this with another sample taken from
ood coal and treated in an exactly similar manner.

B. Take a solid stone, and cut it so that it may weigh just 1
rain, which burn *very gently* on charcoal, before the blow-pipe's
ame, and weigh as before under A.

4. Assaying Coal by Machine.

A. Proceed on the quantity as weighed by difference of
veights B and A, just as by common blow-pipe, under sub-
ieadings A or B, and balance, for percentage, on calculating
.ever.

B. Ignite and burn off, in the crucible, when placed in furnace, (as in Figure 32, page 326,) similar to that of ignition in crucible, as under the first heading of this chapter.

5. The Estimation of the Sulphur Associated with Coal.—This will be frequently found very desirable, for the sulphur is not only disagreeable to those who have much to do with fires, but highly deleterious; as it forms sulphurous acid and various compounds, the products of combustion, such as the sulphides of hydrogen, ammonia and carbon, which attack the iron and copper of steam and cooking boilers so energetically that they are soon rendered useless; and when such coal is used for the production of illuminating gas, many articles, as oil paintings, colored fabrics and silver-ware, become sadly discolored and tarnished.

The following method, recommended by Mitchell, will be found very efficient for your purpose:

> "Process.—1 part of the coal, finely pulverized, is mixed with 7 or 8 parts of nitrate of potash, and 16 parts of common salt, and 4 parts of carbonate of potash, all of which saline matters must be perfectly pure; the mixture is then placed in a platinum crucible, and gently heated. At a certain temperature, the whole ignites and burns quietly: the operation is finished when the mass is white. It must, when cold, be dissolved in water, the solution slightly acidulated by means of hydro-chloric acid, and chloride of barium added to it as long as white precipitate forms. This precipitate is sulphate of baryta, which must be collected on a filter, washed, dried, ignited, and weighed; every 116 parts of it indicate 16 of sulphur."

CHAPTER XVII.

WORKING TESTS FOR GOLD AND SILVER.

In addition to the many practical modes given in the preceding chapters on assaying, those who may deem it more satisfactory to realize corresponding results to large scale operations, may do so, by somewhat similar treatment, with the following, easily obtained, miniature appliances:

AMALGAMATION OF SILVER AND GOLD WITHOUT ROASTING.

Take a carefully averaged and finely pulverized sifted sample of 37,700 grains, which is about 5 pounds and 6¼ ounces avoirdupois, and place it in an assayer's ordinary mortar, a perfectly clean camp kettle, or a prospecting pan, with just sufficient water to form a thick movable pulp. To this you may now add about a quarter pound of salt, one ounce of either bi-chloride or sulphate of copper, with two tablespoonfuls of wood ashes, and grind with a stirring circular motion for two hours.

If the mortar is used, you may stir and grind with the pestle; if the prospecting pan or camp kettle, a common flat iron, as that for ironing linen, if obtainable, will be found most efficient, otherwise a sledge or poll pick will answer. After this pour in a quarter pound of mercury and just a small pinch of bright filings or fine chips of zinc, and again grind for six or eight hours.

The vessel should be kept quite as warm during this grinding as your hands will bear, and the pulp only so moist that the quicksilver will roll or circulate through the mass. This is not difficult to accomplish when two or more persons take turns at the work, and being thus far performed it may be easily completed by removing from the heat, and filling the vessel with *cold* water for settling the quicksilver and amalgam by *slower* stirring of the much *thinner* pulp, for about an hour, when it may be concentrated by side shaking and passing the greater art of the liquid portion over the rim, when the residue ay be closely concentrated by addition of water, &c., in maner explained in Chapter III at page 163, so as to obtain clean ercury, which may be then strained through wet buck-skin to et the amalgam and the silver or gold by flattening it into in cakes and retorting or burning off the quicksilver in a small rucible within a moderately hot fire.

Each grain of silver thus obtained will represent $1 per 2,000 bs. ton, or $24 for every pennyweight, and $480 for every ounce roy. In decimated weights it will be still more simple as $1, 10, $100, $1,000, &c. The value for gold may be known by ultiplying either of these by the whole number of 16. Or 16 imes as much may be taken for the *sample*, which being first arefully concentrated by water to about the quantity used for he silver test, may be treated as described, but quite cold with othing more than the wood ashes, zinc and quicksilver.

Before valuation, the thousandth's fine should be tested by blow-pipe in the manner described at page 321, as the retorted alloy will, like the former mode, also contain copper and zinc.

AMALGAMATION OF GOLD AND SILVER, AFTER ROASTING.

In many samples the associated mineral has such strong chemical holdfast, or so imprisons the silver or gold, that it cannot be separated or extracted before these barriers are removed, and fire is by far the most simple as well as economical and certain means for such purposes; so that, when an ore cannot be worked in raw condition, you may first roast the whole sample in an old wrought iron frying pan, or other suitable vessel, with say a quarter pound of salt, keeping the mass at red heat, during almost continual stirring, for at least two hours, so as to volatilize the stubborn element and chloridize the silver to tractable condition.*

The ore will now be in proper condition for the amalgamation of silver in the manner described for raw ores either with or without the chemicals there named.

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*If the sample should lack sulphur some *outside* sulphuret mineral must be added for more effectual chloridation.

For gold, simple roasting without salt will suffice, and preliminary panning may be done as before stated, so as to greatly reduce the first raw quantity for fire treatment.

For the roasting and chloridizing of gold bearing sulphurets of iron, see method already described at page 334, and Plattner's large-scale process, in the latter part of Volume II.

ESPECIAL AMALGAMATION FOR FREE GOLD IN QUARTZ.

A splendidly speedy and accurate, comparative test, for what can be obtained from free milling auriferous quartz, may be made, by first very *carefully* and *closely* concentrating, in a prospecting pan, the larger of these pulverized quantities, or 86¼ lbs., in suitably small lots, to say about one lb. of heavy residue, and then collecting the gold under an hour's rubbing into an amalgam with about an ounce of clean quicksilver, when after well washing, to settle the mercury and pass away the debris, it may be strained through buck-skin, flattened into thin cakes, retorted and thus approximately valued, or correctly refined for thousandths by blow-pipe and nitric acid, in manners described. Every grain of gold will just equal one dollar per ton.

Prospectors for auriferous quartz veins should highly value this mode, as they may average very *large quantities* and even take 86¼ lbs. for concentration, to at most a pound, and thereby obtain, from the *correctly prepared large sample* and *very small heavy residue* of auriferous matter, very exact results by even this easily performed, miniature amalgamation.

Volume II will treat of large scale operations and processes of Mining and Metallurgy.

GLOSSARY

—OF—

Words and Phrases used in the Arts of Prospecting, Assaying, Mining and Metallurgy.

Account-day. An especial bi-monthly or quarterly meeting of share-holders at the Mine for general consultations and settlements of accounts.

Account-house. The office and boarding-house of the Superintendent, local manager, agents and clerk.

Acetic-acid. Concentrated unadulterated vinegar.

Acicular. Needle-like prisms of crystallization.

Acid. In ordinary sense means, any gas, liquid, or solid that will unite with alkalies, &c., &c., and more or less change or destroy the characteristics of both, by forming alkaline salts, &c., &c.

Acidulate. To render a solution acid by the addition of any appropriate acid.

Acre. A quantity of land equal to 10 square chains. See Chain.

Adit. Adit-level. Shallow-adit. Deep-adit. An especial level for draining one or more Mines by natural outflow of water. (Such a level in Cornwall, called the County adit, which drains several Mines, is upwards of 40 miles long.

Adobe. The Spanish for a soft unbaked brick.

Adze. A double-handed, sharp-edged, curved tool; for cutting and trimming flat surfaces of wood, of somewhat similar action to a common axe, but chamfered only outward, to a chisel like edge; that cuts at right angles to the workman.

Aggregation. The collection of different minerals into one mass, which may, however, be mechanically separated.

Agglutinated. Joined by gluelike cementation.

Air-compartment. A separate—air-tight part—of any shaft, winze, rise, or level, for improving ventilation.

Air-door. A door for the regulation of currents of air, through the workings.

Air-cushion. Spring caused by confined air. See Phillips's Hydraulic pumping engine, Volume II.

Air-engine. A machine power very similar to steam engine, but worked by compressed air.

Air-fan. Revolving fans, driven by an axle, for extracting and supplying air by rapid revolution.

Air-furnace. A fire placed at the surface, fór drawing out foul air from shafts or levels by its natural draft for combustion.

Air-gate. An air regulator, by hinged or sliding gate or door.

Air-hole. A hole drilled in advance to improve ventilation by such partial communication.

Air-jigging-machine. For separating ores, without water; by intermittent upward puffs. See Second Volume.

Air-machine. Any mechanical appliance for forcing in pure air or extracting foul gases. See those in Volume II.

Air-oven. A heated chamber for drying samples of ores, liquids, &c.

Air-pipe. An air-tight wooden pipe or metal tube, so laid as to convey air to or from any particular place.

Air-pump. Used in laboratories for extracting air, and for steam engines to assist in keeping better vacuum in condenser.

Air-shaft. A hole sunk for the especial purpose of supplying air to the advancing end of a long tunnel, by chimney-like draught.

Air-sollar. An air-tight wooden floor, so placed under feet, that sufficient space will still intervene above the rock bottom, for the cold water to cause a constantly inward flowing current of refreshing air, to replace that in the level.

Alloy. Two or more metals melted into one homogeneous piece.

Alluvial. Relating to the deposits by water; of clay, sand and gravel.

Alluvium. Alluvion. Gravel, sand, clay, &c., deposited by water, and now more or less solidified upon older formations. As the auriferous alluvions of California are far too irregular in width and vast in extent for any less restricted alluvial cause than the ocean itself. See Chapter 4, page 56.

Alta. The Spanish word for the upper or hanging wall of a vein.

Alumina. Oxide of Aluminum. Alum. Clays are highly aluminous, when most suitable for crucibles, fire bricks, &c.

Amalgam. Wet-amalgam. Dry-amalgam. Crisp-amalgam. Retorted-amalgam. The various *degrees of union* of fluid mercury with gold, silver, copper, &c.

Amalgamator. One skilled in the reduction of ores by amalgamation. Also, by personification it may be said that the Mexican Arrastra is a good amalgamator but indifferent grinder, or the Chilean-mill is passably good at both grinding and amalgamating.

American horse-whim. The Cornish whim inverted, so that the cage and rope shall lie beneath the horses' feet, &c. See page 151.

Analysis. Chemical analysis divides matter into separate elements.

Angle-beam. **V-bob.** A strongly built double-limbed beam, tied as *one* by bridles, for turning angles in shafts, &c., by connected pump rods, &c.

Angles, Dips and Spurs. The side-extent which can be claimed upon a mineral vein is expressed by this phrase.

Anhydrous. Waterless. As anhydrous acids, salts or minerals.

Anneal. To soften by slow cooling, by a warming and dipping some metals.

Anqueras. An appendage in the rear of the Mexican saddle, generally made of goat-skin, with the wool hanging gracefully downward.

Antimony. A metal. Symbol Sb. Atomic weight 129.

Anvil. A heavy block of iron upon which blacksmiths forge articles of wrought iron to any desired shape.

Aparejo. A kind of pad or mat, cinched upon a beast of burthen.

Aqueduct. An artificially built, elevated way, for carrying water across uneven ground or valleys.

Aqueous. Containing water, as a watery or aqueous solution.

Arbor. An axle which partially or wholly revolves.

Arborescent. Tree-like formation of minerals.

Arch. A circular form of rock intentionally left standing for the more certain support of the overlying rock or vein.

Argentiferous. That which contains or yields silver.

Argol. **Crude-tartar.** An acid salt deposited from wine, upon casks.

Arm. **Horse-arm,** &c. The bar to which a horse or anything is attached.

Arrastra. A Mexican crushing or amalgamating machine, consisting of a circular trough wherein stones are dragged round after a transverse arm revolving upon a vertical central stem or axle, as worked by horse, steam, or water power.

Arrears. When assessments or calls are unpaid.

Arseniate. Arsenic acid united with a base, &c.

Arsenic. A metal. Symbol As. Atomic weight 75.

Arseniuret. **Arsenide.** Arsenic in chemical combination with some base; as, *mineralogically expressed*, arseniuret of iron; and *chemically*, arsenide.

Artesian-well. A deep well for obtaining water from beneath the compact stratification of the overlying rock, as supplied by pressure from the distant side hills or mountains.

Assay. **Assaying.** Reducing minerals to metals in a small way, for ascertaining their real working or commercial values upon the large scale.

Assaying-furnace. See page 283, for such a furnace as made of bricks.

Assessment (American). **Call** (Cornish). Levy on share-holders for obtaining the necessary working capital.

Assortment. Intelligent separation of minerals for grades of quality.

Atomic weight. See Equivalent numbers.

Attle. **Addle** (Cornish). Castaway rubble after assortment.

Attraction. A drawing to; as the attraction of gravitation, cohesion, &c.

Attrition. The act of wearing away by any kind of friction.

Auditor. An especially appointed examiner of accounts for the general interests of the share-holders.

Auger. A very useful, double handled, half cylindrical carpenter's tool, with a solid cutter at the entering end; mostly used for boring deep holes in large sticks of timber, as beams, pump rods, &c.

Auriferous. Gold bearing, as auriferous quartz, cement, gravel, sand, mud, &c.

Avalanche. A large mass of snow sliding or slidden over a mountain's side.

Awl. A small, slightly bent, sharp pointed steel tool, placed in a handle, and used for piercing holes in leather when sewing belts, &c.

Awning. A temporary canvas overspread, for intercepting the rays of the sun, rain, &c.

Axe. A long-handled or double-handed hatchet, used for roughly cutting large pieces of timber, firewood, &c. (Cornish Dag).

Axle. **Axle-tree.** The central bar, on which the outer shell or axle-box revolves.

Axle-box. The thimble or shell that encloses and turns upon its central axle.

Azoic. The age of the rocks which were formed before any animals existed.

Back. The overlying sections of veins and bed-rocks; as there is a large reserve of ore in the old backs of the 1,000 foot level.

Bag. A small sample sack.

Baize. A coarse common cloth used for lapping or wrapping the iron joint-rings for more securely connecting the flanched pipes of Cornish underground pumps.

Bal. Cornish word for mine. Also in the old names of mines, as Balnoon; Balleswidden; Bal Dhu, &c. See also Huel and Wheal.

Balance-box. A large box placed at one end of a long and strong lever, which works upon a central axis or gudgeon, and connects at the other end with the rod that requires lifting up or balancing; as mostly used for counteracting the great weights of pumping-rods in deep shafts.

Bar. A ridge deposited in a river's bottom, either lengthwise or diagonally across. Also applied by miners to a "hard bar of ground," when the rock gets a harder belt than is usual for that mine.

Barley-sacks. Much used in winter by shrewd travellers for wrapping over the boots to keep their poor feet warm.

Barometer. An instrument for ascertaining the heights of mountains, and anticipating rain or wind storms, by varying pressure of atmosphere.

Barrel amalgamation. Amalgamating in revolving close barrels as fully described in the Second Volume.

Barrow. A box with two handles at one end and a wheel at the other.

Base. Any element or substance with which an acid will unite.

Base-metal. Not one of the precious metals of gold, silver, platinum, &c.

Basin. Hollow. Flat. A natural surface-hollow or flat place, where minerals may lie; as Bear Basin, or the hollow at the source of the Ashlet River, Vancouver Island; Dutch Flat, California, &c. Also a surface basin of mineral or auriferous gravel. See page 118.

Bastos. Two wide strips of leather attached beneath the Mexican saddle, for protection of the back of the animal.

Batch. An assorted pile of ore; sometimes called "doles" when divided in equal quantities.

Batea. A wooden bowl much used by Mexican, Peruvian and Chilian miners for testing small quantities of auriferous sand or quartz by water concentration.

Batten. A piece of thick board of less than 12 inches in width.

Battery. Mill. Stamps. See Mill.

Beak-horn. The peaked or conical end of an anvil, used by smiths for making different sizes of rings, chains, &c.

Bed-rock. The actual rock; over or in which, gravel deposits, mineral pockets, and veins lie.

Before-breast. Rock or vein sections, which still lie ahead and unbroken.

Bee-line. The nearest possible distance; as the loaded bee would fly home.

Bell. For informing workmen when to come to or quit work.

Bellows. A bottom and a middle board with clack valves, and one solid top board, hinged together at the nozzle end, and surrounded by leather. The bottom is moved by a brake staff, and this causes the top board to rise and force air continuously out through the noze into the fire.

Best-upon-trust. That miserable *substitution for contract*, when a foreman says, "Do your best, men, and trust to me for making right at the end of the month." An elastic system for fooling with employers and men.

Bi. Bin. Di. Twice or two of; as the di or bi-chloride of copper, bi-valve, bin-oxide, &c.

Bin. A convenient box with cover, used for tools, stores, ore, &c. See Bi.

Bismuth. A metal. Symbol Bi. Atomic weight 213.

Bitumen. Bituminous Slate or Shale. Mineral pitch. Charged, more or less, with mineral pitch.

Black-jack. The common Cornish name for the sulphuret of zinc.

Blacksmith's Shop. The workshop for making and sharpening tools.

Blanket-straps. Strips of leather with metallic buckles, for securing a roll of blankets for travelling.

Blast-pipe. A pipe for supplying air to furnace fires.

Blind-lode or vein. Having no visible croppings. Hidden beneath the surface, and only attained by digging.

Blow-pipe. A wonderfully efficient mouth instrument for assaying and testing minerals by miniature blast and flame, with suitable fluxes, &c.

Blow-pipe-pestle and mortar .Asteel bed-plate, cylinder and pestle; so fitted that none of the powder can escape when the stone is crushed by repeated blows from a hammer.

Bob. The Cornish name for lever or beam.

Bog-iron-ore. An iron ore found under bogs and marshes.

Boiler. Steam-boiler, &c. A suitable vessel for boiling under pressure.

Bonanza. An unexpected and valuable prize, as a large body or deposit of profitable mineral or metal, in one particular place or section of bed-rock or vein. (Mexican and Spanish.)

Bone-ash. Burnt bones, pulverized and sifted for use in cupelling.

Borate. Boracic acid in chemical union with some base.

Bore. To drill, as boring for oil, water, blasting, &c.

Boss. The U. S. name for Superintendent or Foreman.

Bottom. The sections under foot; as the bottom of the level, winze or shaft.

Botryoidal. In grape-like bunches, or dotted clusters.

Boulder. A large and smooth rock, rounded off as if water-worn.

Boundary. The surrounding lines, marking the extent of property as granted by the English "Landlords," to miners, who may only work what comes within vertical lines thereunder, instead of *indefinitely continuing* upon the vein, *under legal doubt*, as in this country.

Boyer. The name by which the common rock-drill is known to Cornish miners.

Brad-awl. A steel wire-like chisel-pointed tool, fixed in a handle; for drilling small holes in wood.

Brake. To retard by friction, as produced by a combination of levers and straps or rubbing pieces.

Brass-holes. The suction-holes of the wind-bore of a pump.

Breakstaff. The lever for blowing a blacksmith's bellows, &c.

Breast. Breasting. The standing end of rock or vein, or cliff of gravel, immediately before; and taking down or blasting such ground is called breasting.

Breccia. A cemented rock composed of angular fragments of one or more minerals, which generally exhibit different colors.

Brick. For building houses, furnaces, &c.

Brick. Bullion cast into brick shape.

Brick-mould. For shaping or casting the various bricks.

Brittle. Not tough; and, however hard it may be, it breaks very easily.

Broad-axe. A long-edged axe, used for vertically trimming and squaring the sides of large timber. A very useful and efficient tool when skillfully used, for such "backwood," far interior purposes.

Brown coal. Imperfectly formed young coal; as the "Lignites," which are brown when finely pulverized.

Bucket. Applied to several things that contain; as the bucket for hoisting rock; water bucket; the buckets of a water-wheel; to kick the bucket, &c.

Bucket-rod, and prong. The fork-ended rod attached to the bucket. See Volume II.

Bucking-bench. A long earthwork bench of suitable height for receiving the bucking-irons.

Bucking-hammer. A 5-inch square disk with a side eye for receiving a handle, as used by the Cornish mining girls for breaking the minerals to suitable sizes for the market.

Bucking-house. A shed for buckers or ore crushers.

Bucking-iron. An iron bed of 12 inches square and 2 thick, used for hammering upon when crushing the ores.

Buck-skin. The untanned or raw skin of the deer, used for straining mercury (quicksilver).

Buddle. A long, slightly descending, box; used in the water concentration of ores.

Brunton's round buddle. This differs from the common buddle by having a circular pit, and a central axis, that lets out the water as it rotates a cross arm with ribbons or soft brooms, which by also rising with the slowly accumulating ore, continue to pass the lighter portion outside and away, whilst the heavy is concentrated by retention at the centre.

Bugles. Two strong half-circle clasps, with suitable screws, for hugging by sure grip, pump columns, or when retaining in position or raising and lowering heavy pumps.

Bullion. The metallic product from mines. Precious bullion is of high thousandths fine and base bullion is low grade.

Burrow (Cornish). The general pile as hoisted from a shaft or mine. The same as the American "dump."

Burr-stone. A peculiarly hard and cellular silicious stone, used as mill stones, for grinding corn and minerals.

Bushel. A dry measure, much used in mining and metallurgy; it contains 2,150.42 inches, and a box of 13 inches in length by 13 inches wide and 12¾ high will be a very nearly correct measure.

By-level. A side level driven for some unusual but necessary purpose, as where the first level has been dangerously and irreparably crushed.

By-pump. A side pump for help or safety.

By-rod. A side rod for some additional and separate work.

Cab. The first side parts of a vein, nearest the walls, which are generally hard and deficient of mineral.

Cage. The cage or hollow drum of a horse whim, for carrying the rope when hoisting from mines.

Cage. Gig. A light box made of iron plate and bars, for hoisting men, &c.

Cake. Caking. To cake or stick together in roasting, &c. A cake of amalgam. Caking coal, &c.

Calcine. Calciner. To burn off or volatilize. The Cornish name for the revolving calcining furnace. See Second Volume.

Calcium. The metallic base of lime. Symbol Ca. Atomic weight 20.

Calc Spar. A pure, crystallized, carbonate of lime. Sometimes found as a matrix in veins, &c.

Callipers. A kind of bow-legged compass for measuring sizes.

Cam. A tappet or curved eccentric slip block for raising and dropping battery stampers or pestles.

Can. A small cylindrically shaped tin vessel; especially used as a powder-can, drinking can, &c.

Canal. A larger water channel than a ditch, leat or flume.

Candle. Miners' candle. An especially made candle, having an extra sized wick and more tallow for giving better and more certain light.

Cann. A very fine and soaplike white clay found upon the joints and within the seams of lodes. A good indication for minerals.

Cantanas. Double pockets of leather with a hole in the middle so that they may be thrown over the horn of the saddle to hang at each side. Sometimes covered with fancy wool pendants, of goat-hide, &c.

Canteen. A traveller's water can, of cheese shape, and corked at the edge.

Cañon. Canyon. A narrow gorge or valley. (Mexican and U. S. American.)

Capillary. Mostly used to express that irregularly crooked and fibrous form of native metals; appearing somewhat like the filigree work of jewellers.

Cap-rock. The uncertain upper rock that covers the older bed-rock.

Capstan. A vertical axle, worked by men forcing against its horizontal arms, for heavy hoisting and lowering.

Captain. The Cornish name for American "Boss."

Car. A wheeled wagon for conveying rocks, dirt, ashes, slag, &c., upon rails. (Cornish, tram wagon.)

Carbon. Symbol C. Atomic weight 6. See Graphite, and page 227 and 245.

Carbona. An expressive word in some Carbona Mines of West Cornwall, for a rich pocket of mineral in the country rock, as connected with the lode by a mere thread of mineral. A *bed-rock bonanza.* See pages 96 and 97.

Carbonate. Carbonic acid combined with a base, as carbonate of lead.

Carbonate of Soda. Carbonic acid and oxide of sodium chemically combined.

Carbonic acid. Symbol $C O^2$. Atomic weight 22.

Carboniferous. Carboniferous slate or shale. Containing a little carbon. Indicative of underlying coal seams.

Carga. Cargo. The Mexican miners' measure of weight for ore broken on contract (300 lbs.). An animal's load.

Carpenter's Shop. A suitable house for the workers on wood.

Cartridge. A metallic or paper, cylindrical shell, for containing powder; made just the size of hole, as drilled for blasting.

Catarack. A kind of water clock used for varying and regulating the, between stroke, time of the Cornish pumping engine. See Second Volume.

Catch-pit. A reservoir for saving tailings from reduction works.

Caunter-lode. A vein running obliquely across the regular veins of the district.

Caved. When the rock of a level or tunnel crushes together.

Cellular. When a stone of mineral has many small cavities.

Centigramme. The one-hundredth of a gram.

Centrifugal-force. Flying off from the centre, is the force as developed in practice; but it is really caused by each atom endeavoring to keep in a straight *tangential* line, during the revolution of the body.

Centripetal-force. Drawing towards the centre.

Certificate. The paper issued by a Secretary and signed by the President or Trustees, for the number of shares of stock. In U. S. America these shares are then simply passed from the *nameless* seller, to the broker and buyer like bank notes, but in England it is only a receipt. See Transfer.

Chain. Many iron links so connected as to form a long string or piece for hoisting from great depths. An iron or brass linked measure used by surveyors. Its length is 66 feet and usually divided into 100 links.

Chamois-leather. Untanned or raw and soft buckskin, used for straining mercury, &c.

Changing-house. For miners changing their clothing.

Chaparejos. A front covering for the pants with belt and pockets made of calf, goat, llama or sealskin. Very useful for screening the legs from rough brushwood.

Charcoal. Wood partially burnt to carbon, in a stifled slow fire; much used in furnace smelting and blow-pipe assaying.

Charcoal-borer. A short piece of quarter inch square bar, having a sharp cross-shaped cutter at one end. Used in making blow-pipe assays.

Chatoyant. A changing, cats-eyelike, play of light; as precious opal.

Chisel. A sharp instrument for cutting wood, rock, or metal, when held in the hand and struck with the hammer.

Chispa (Spanish). For a distinct metallic particle; as a nugget.

Chloride. Chlorine chemically united with some base; as chloride of sodium, or common salt.

Chlorine-gas. A pungent gas that unites with cold water, and then dissolves gold. The hot gas has no affinity for gold. Symbol Cl. Atomic weight 35.5.

Chloridize. Chlorinate. Chlorinize. To cause chlorine to unite with a base, as in the hot fire-chloridizing of silver and the chlorinizing of gold by cold chlorine water. Chlorinize and chloridize have been used in this book, as they are more chemically correct than chlorinate of the present dictionaries, because there is no oxygen in the compound to require the termination of *ate*. Oxygen has been changed to oxidize, and although chlorine and chloride are already suitable for the correct suffix, chlorinate has been erroneously created.

Choke-damp. Carbonic acid gas, which extinguishes a candle and suffocates men.

Chromate. Chromic acid with a base.

Chute. Shoot. Shute. A wood or metal pipe, or a hole in the country rock or vein, for passing down rock and debris to a plat or immediately into convenient cars. These words have been also used when speaking of the positions of mineralized portions or sections of veins; but they are sadly deficient for the triple meaning which should be conveyed. The English language fails to express the idea by any single word. I think *range* of ore would be much closer to the real thought.

Cinch. Cincha. A word in very common use amongst horsemen and packers, and used as substantive and verb; as the cinch (or tightening strap) of my saddle is loose. You should cinch your mule tighter for this rolling country.

Clack-door. A convenient door which may be readily unscrewed and taken off for fixing or examining valve.

Clack-seat door-swing. A chain for swinging doors.

Clack-seat piece. The cast iron receptacle for seat and valve.

Clack-valve. A valve moving from a leather or iron side hinge centre, somewhat like the clack of a bellows. See several kinds in Volume II.

Clack-valve seat. The seating ring for making the water-tight joint under valve.

Clasp. A snugly fitting ferrule for firmly connecting, enclosing, clasping and securing two pump rods together as one.

Clasp and pin, rod-joint. Slightly *overlapping* flat rods secured by a snugly enclosing lengthwise *ferrule* and a riveted or screwed *cross pin*.

Clasp and step, rod-joint. When the rods clutch in cross steps and are then hugged together by the external ferrule.

Clasp and tongue, rod-joint. When the tongue or key of one rod lies in a corresponding recess of the other, and both are then firmly kept together by external ferrule.

LASP AND WEDGE, ROD-JOINT. When *reversed* wedges are held together by a strong external clasp.

LAY. Chiefly composed of alumina, in a moist and putty-like, or dry pulverulent condition.

LAY COURSE. Mostly applied to an accompanying clay seam or "gouge" by the side of a vein.

LEAVAGE. The planes at which cleavable stones break. Degrees of cleavage, as perfect or imperfect, easy or difficult.

LIFF. A blacksmith's chisel, &c.

LUB. DOCTOR AND CLUB. A generally favored institution of the mines of Cornwall for mutual assistance in cases of accident to life or limb, where one shilling per month is deducted from every man for such accidental purposes of aid, doctor and burial. A most provident and necessary practice which should be adopted in all mining regions.

COAL. An important, natural stone, fuel. See page 220.

COBALT. A magnetic metal. Symbol, Co. Atomic weight, 29.5.

COBBING-HAMMER. A short-handled, double-ended and long hammer, for breaking rocks to sizes.

COHERENT. Firmly held together, not friable. A brittle mineral may be strongly coherent to a *steady* strain.

COG-WHEEL. A wheel having teeth for working into another wheel.

COIN. COINAGE. Metallic money. The weighing, shaping and stamping of the standard metals.

COKE. Genuine coals partially burnt in close vessels. The fuel used for strong, enduring heats, as smelting iron in foundries, assaying, smelting ores, &c.

COLLAR. The first, or the surface wooden frame of a shaft.

COLUMNAR. COLUMNAR CONCRETIONS. Crystallizing in columns, as basaltic lava, some of the iron ores, &c.

COMBINED. COMBINATION. United by chemical affinity into known fixed ratios and not in mechanical chance or irregular quantities.

COMPACT. When a stone is all alike and not cleavable.

COMPASS. A two-legged sharp-pointed tool for scratching or drawing circles. See also Pocket compass.

CONCENTRIC. CONCENTRIC LAMELLAR. Having been formed by distinctly visible circular layers, or laminations from a centre.

CONCHOIDAL. Fracturing to irregularly shaped surfaces like flint, &c., without any sign of plane cleavage.

CONCRETION. Cemented aggregation of one or more kinds around a centre or central nucleus.

CONDUIT. A covered water way.

CONDUIT-HOLE. A flat hole, drilled for blasting up a thin piece, in the bottom of a level.

Conglomerate. Pudding-stone. A concretion or cementation of rocks, pebbles and sand.

Constitution. Constitutional form. Certain ratios of chemically combined elements, and thus differing from mechanical chance. See "Symbol," "Atomic weight," and "Equivalent numbers."

Contact-lode. A vein lying between two differently constituted rocks, as granite and slate, &c. I have substituted the name of *Intervening-lode* in this book as a better and more easily understood expression.

Copper. A red metal. Symbol, Cu. Atomic weight, 32.

Cord. Cord-wood. Wood stacked just 4 feet wide, 4 feet high and 8 feet long, which will equal a "cord" of 128 feet.

Cost-book system. The leading system used for Cornish mining; where all expenditures, liabilities and receipts must be promptly entered into the "cost-book" and then left open and "*above board*" for even the smallest stockholder; as any *one* is liable for *all* debts and must have fair play.

Counter. An apparatus for counting or recording the number of strokes made by the Cornish pumping engine. See "Duty."

Cradle-rocker. A box somewhat similar to a child's cradle, wherein the gravel is first placed upon a hollow perforated pillow and rocked with water, when the gold is retained near the head after the large rocks are first washed clean and thrown out whilst the dirt passes away in the water.

Cribbing. The thin timber lining outside the sets of a shaft. Taking rich stones from other men's ore.

Croppings. Portions of a vein as seen exposed above ground.

Cross-course. A vein lying across the regular veins of a district, and generally poor within itself.

Cross-cut-saw. A peculiarly shaped, widely set, and equally angled, coarse toothed saw; for cutting forward and backward, across logs of timber.

Cross-cut. Cross-cut-tunnel. A level driven across the veins or regular workings.

Croust. A very important item in the Cornish miner's operations, as it is his lunch. Sounded *crowst*, derived from crust, and it unfortunately has, almost invariably, much more crust than meat.

Crow-bar. A strong iron bar with a slightly curved and flattened end; used for levering out stones, moving heavy weights, &c.

Crown-wheel. The large wheel in a system of cog-wheels, but more appropriately so, when it is a bevel wheel.

Crucible. A small barrel sided vessel used for assaying, composed of clay, plumbago or iron. See page 373.

Crupper. A band passed under the tail of an animal and attached to the saddle or pack-saddle to prevent its slipping forward.

Culm. A kind of anthracite coal, used in smelting oxide of tin, &c.

Cupel. A moulded cup of bone-ash for cupelling or purifying gold and silver, by oxidation of the base metals.

Cupel-mould. A cylinder of metal for holding the moistened bone-ash when it is being stamped or compressed to shape by the suitably formed pestle.

Cupel spring-grip. A spring holder for moving cupels into, or from, the muffle. See Phillips's general purpose spring-clip on the the left side of furnace, page 283.

Cupel-tongs. A light and long, U-shaped, tongs; for handling cupels.

Cupriferous. Having or containing copper.

Cut. Open-cut. To strike or reach a vein, &c. To take up a cut, as in cutting out for a foundation of walls in a side-hill, or for excavating the open cut of a railway.

Cwt. Abbreviation for the English hundred weight of 112 lbs.

Dag. The Cornish name for a heavy, single or double handed hatchet; much used by skilled miners in cutting timber. A funny story has been told of a Cornish captain insulting a military gentleman, who desired him to name weapons for mortal combat in a duel, when he promptly replied that he had no wish to fight, but if he must do so, "*Dags*" should be the weapons! This was too ridiculous for red coat, and no purple blood was shed.

Dam. An embankment for stopping back or pooling up the water of a river. Subterraneous dams are made of stone or wood in a wedge form, so that the coming, or back pressure, may keep it perfectly secure and tight. See also wing-dam.

Damper. A sliding door of iron for regulating the draught to steam engine and other furnaces. An Australian camp-bread, hastily baked by being placed within hot ashes.

Debris. Fragments from any kind of disintegration.

Decigramme. Decigram. The one-tenth of a gram.

Decomposed. That which has undergone artificial or natural change; as the desulphurization and oxidation of the sulphuret of iron, &c.

Decomposing. Any substance now undergoing some chemical change.

Decrepitate. To burst, with crackling sounds, into many pieces.

Deed. Lease. The landlord's grant to Cornish miners, which generally extends to 21 years, for *one-eighteenth* of the *total* mineral proceeds.

Delinquent. Passed the advertised legal time for payment of assessments.

Dendritic. Arborescent. Shaped, or crystallized, like trees.

Denudation. Mountains and hills laid bare to the bed-rock by wind, water, snow or glacial action.

Deposit. What has been in some way dropped into position; as heavy deposits of gravel, sand, mud, coal, &c.

Derrick. An elevated appliance of pulleys or power for hoisting various heavy things.

Detritus. Finely powdered deposits worn from hard substances and distributed over large areas, by some unusually powerful or long continued action.

Deut. The same as Bi or Bin. The deut or double oxide.

Dial. A simplified theodolite more especially devised for Cornish miners' underground surveying; as Phillips' Miners' Dial.

Die. The bottom iron block of a battery upon which the shoe or pestle strikes. (Californian, *shoes* and *dies;* Cornish, *heads* and *grounds.*)

Diggings. Gold-diggings. Where gold and other metals or minerals are dug out.

Dike. A large zone of vein-like formation, but composed of bed-rock or country instead of matrix.

Diluvium. Deposits of pebbles, gravel, sand, clay, &c., as drifted to present position, in long past times, under ocean's wash.

Disintegrated. Separated by mechanical means; not chemically decomposed.

Disjointed. Broken rock, with numerous joints and facets.

Directors. Trustees. English director; American trustee; elected by shareholders as a managing committee of, generally, five. Also, for showing the public the degree of respectability.

Disseminated. Lying variously therein; as equally or unequally disseminated, &c.

District. Any mineral-bearing area subject to one recording office.

Ditch. An excavated *narrow channel* for carrying water.

Diverging. Divergent. Lines or crystals diverging from a centre.

Divide. The top of the ridge, hill or mountain; where rain water is separated.

Dividends. The profits given. Dividends infatuate more than assessments deter.

Divining rod (Cornish, **Dowsing rod**). A small and forked hazel twig, which when loosely held in the hands, is erroneously supposed to bend downwards when passing over a vein of mineral. See Dowsing rod.

Doles. Small piles of assorted or concentrated ore.

Dope. A slippery paste used by expert snow-shoe travellers for rubbing under the long snow-shoe keel-runner so as to increase speed.

Dove-tail joint. Mortised by dove-tail or reverse wedge-shaped ends, closely fitted into corresponding recesses or holes.

Dowsing rod. A folly of past ages, exploded by modern science; see the Divining rod.

Drag. Drug. A retarding appliance or brake, or something drawn behind for this purpose, when descending hills.

Drift. A tunnel cut through the rock. Accumulations of debris, drifted by wind or water.

Draw-bridge. A bridge that may be withdrawn from a river or ditch so as to stop passage at pleasure.

Drawing-knife. A long knife with a shank at each end, so bent and handled like the limbs of an Γ, that the cutting edge may be used with great force and speed for roughly trimming and shaping wood.

Drawing-lift. A pump that receives its water by suction and which will not force it above its head.

Draught pump. A suction pump. See Drawing-lift.

Dressing-floors. Especially graded plats for assorting and receiving ores.

Dry. A suitable house for drying miners' clothes by fire. See Volume II.

Dry-amalgamation. Treating ores with hot and dry mercury, instead of in water as by the usual way.

Drusy. A mineral covered with small crystals.

Dues. The percentage or ratio the landlord receives.

Dump. The pile of refuse rock as discharged from shaft or tunnel (Cornish burrow).

Duty. The officially reported "duty," or *work done* by Cornish engines, as told by the Official Reporter and "*Counter*," which see.

Earthy. Like earth or soil, in appearance of fracture and powder.

Elastic. Springy. Bending and springing back; see Mica, page 241.

Electric blast. Instantaneously blasting one or more holes by the electric spark as passed into the powder by wires. See the suggestion as given in 1st Edition, Vol. II under Deep Mining, which has been recently used.

Elvan (Cornish). Elvan course or dike. A fine-grained feldspathic rock of blue, green, or yellow color; said to be beneficial to copper veins, at and near such intersections.

Elbow-piece. A piece of any pipe or material angled like the elbow.

Elbow-pipe. A pipe bent like an elbow for turning the direction.

Emarginated. When crystals have the edges of their primary forms chamfered away or truncated by another face.

Emerge. To arise out from.

Engine-pool. A reservoir of water for supplying the engine.

Engine shag. A coarse cloth, similar to baize, used by miners for lapping rings to intervene screw-tightened flanches and secure water-tight joints.

Equivalent-numbers. Atomic weights. The comparative weights of the different elements, as used in calculating the proportionate results from chemical analysis.

Era. Epoch. A period of geological time, &c.

Erect. To place buildings or machinery in position.

Erode. Eroding. Erosion. Scoop, scooping, scooped; as the persistent rains have greatly assisted in eroding or scooping out the valleys.

Faces. Facets. Large and small faces, planes, joints or seams; as seen in the most interesting, mineral yielding, bed-rocks.

Fasciculated. In bundles of fibrous, needle-like, crystals.

Fault. A cut-off and shift of the vein or seam.

Feeder. A splice of quartz lying in country but connected with the lode at the bottom end.

Feed-pump. A small pump for forcing in the water to steam boilers.

Fend-off. A sort of bell-crank lever for turning a pump rod past the angle in a crooked shaft.

Ferruginous. Irony, iron oxide, rusty stains.

Fibrous. Having the appearance of being composed of more or less compact fibres, as the silk-like asbestos, petrified wood, &c.

Filiform. Filamental. Thread-like.

Find. Strike. To find, or having found a valuable vein or deposit. To strike it rich.

Fire-bars. The iron bars upon which the fire lies.

Fire-brick. A heat-resisting brick, made from aluminous clay, graphite, &c.

Fire-damp. The carburetted hydrogen, explosive gas, of coal mines.

Fire-whim. The Cornish name for the steam hoisting engine.

Fissure. An extensive crack or chasm in somewhat regular plane of fracture, as a "true fissure vein."

Flap-jacks. Hasty made and most unhealthy bread as baked in a frying pan before the fire, just for the ridiculously rough meal of poor prospectors.

Flat-rod. A horizontal rod for conveying and using power at a distance.

Flexible. Bending freely without fracture, but not elastic.

Float-stones. Shoad-stones. Mineralized stones lying upon the surface over or near veins and deposits, which sometimes direct the prospector to valuable mines.

Fluate. Fluoric acid in combination with a base.

Fluocan. Prian. Fine clay; as permeates through, and lodges in, the joints of veins. A supposed good indication for value.

Flume. Bed-rock flume, &c. Terms much used in "Gravel Mining." A long artificially made river having either a bottom of wood (endwise), iron (lengthwise), or stone; and descending not less than six inches in twelve feet. These bottoms are occasionally cleaned up for the gold thus intentionally caught in the interstices, during the passage of the water with rocks and gravel.

Fluvial. Fluviatile. Formations of, and deposits from, rivers.

Flux. Any substance that is favorable to fusion, oxidation, or reduction by fire.

Foliated. Lamellar. Leaf-like or book-like in form; which can be cleaved.

Force-pump. Any *close* pump that forces water above its valves, as the Cornish "plunger pump."

Forge. A blacksmith's fire place and stand.

Fork. Going in fork. A deep receptacle in the rock so that a pump may extract the bottom or drainage water. A pump is "going in fork" when the water is so low that it sucks *air* through the "Brass holes," which see.

Fossil. Organic remains changed into stone; as a fossil of animal or plant.

Fox-wedge. A wedge with its point outwards, so that it will tighten into the end of a bar of wood or metal as the latter is driven inwards into the same hole.

Fracture. Applied to qualify broken surfaces of minerals, as tabular, conchoidal, earthy, even or uneven fracture.

Frame-concentrator. An oblong frame of slight declivity, swung lengthwise on central trunnions, for occasional tipping as required. Much used in Cornwall for dressing or concentrating the oxide of tin by water.

Frangible. Easily broken; brittle; not tough.

Friable. Any mineral of slight coherence, or which can be easily broken, and also when speaking of the fact of such rock being found in a friable state or condition.

Fungiform. Having the form and appearance of organic funguses. Like mushrooms.

Furnace. A suitable fire-place for smelting, roasting, chloridizing, assaying, &c. See page 283, and Section V, Volume II.

Fusibility. The more or less difficult melting of minerals; as partially or entirely fusible. Slightly fused on edges. Infusible, &c.

Gad. A small wedge of the size and shape of the point-end half of a pick, used for driving into cracks when loosening jointy ground.

Gangue. **Waste.** All the kinds of enclosing waste rock. The matrices of quartz, &c., are also gangues, but gangues may not all be matrices.

Gas. Any air-like elastic vapor; as coal gas or carburetted hydrogen.

Gasket. A closely interwoven white yarn rope, as made either oval, round or square, as best suited for packing steam pistons, water pumps, &c.

Gauge, Any instrument for measuring quality or quantity of solids, liquids or gases; as, "Phillips's copper ore standard gauge," &c.

German-key. A long iron rod with a transverse and spirally crooked end, used for fishing up a bucket prong when the bucket rod is broken.

Gimblet. A small screw-pointed tool, fixed in a cross handle of wood, for boring holes in timber.

Giraffe. A mechanical apparatus for receiving and tipping a car full of ore or waste rock, when it arrives at the surface.

Glance. Sometimes applied to glancing or shining materials; as copper glance, lead glance, &c.

Gland. The upper part of a stuffing-box, as movable by screws.

Globular concretions. Minerals occurring in small rounded forms.

Glue. **Glutinous.** An adhesive liquid for joining wood, &c. A glutinous or sticky liquid or substance.

Gold. A yellow metal. Symbol, Au. Atomic weight, 199.

Goose-neck-pipe. A pipe for discharging water, &c., of goose-neck shape.

Gossan. Friable ferruginous quartz. Very rusty and finely broken quartz, which is thought one of the best indicators for mineral in deeper sections of the vein. (Cornish.)

Gouge. A carpenter's chisel of semi-circular shape. A soft clay seam beside a vein, cross course, or slide, and so called because it can be gouged or scooped out.

Gramme. **Gram.** Equal to 15.433 grains troy or avoirdupois.

Granular. When minerals expose small grains across the face of fracture.

Graphite. Mineral carbon. See Alphabetical Chapter, page 227.

Grass. The surface of the ground; as my comrade has gone to "grass," or to the surface. (Cornish.)

Greasy. **Unctuous.** Slippery and otherwise of grease-like appearance.

Green-stone. A green colored granular stone, a kind of trap, composed of hornblende and feldspar.

Griddle. A coarse sieve used in jigging ores, sifting clay for mortar, &c.

Grinding-stone. A cheese shaped fretting stone, turned by a crank handle for sharpening the heavier edged tools.

Ground. **Country.** **Bed-rock.** As we are working on ground, &c., not in the vein. The rock in which veins are enclosed.

Grounds. **Dies.** **Bottoms.** The beating bed irons under the pestles in the mortars of batteries. (First and last Cornish.)

Ground-sluice. A long box, with suitable chinks for retaining the gold, as used by gravel miners for washing away large quantities of auriferous debris.

Growan. **Marl.** The Cornish name for a soft and decomposed ferruginous feldspathic granite

Gudgeon. The heavy central axis of levers, beams, &c.

Gutter. **Gutter-way.** A small groove or water-draining channel.

Guy. **Guy-rod.** A stay, of rope or chain, rod or wood.

Hade. **Dip.** **Underlie.** The angle of the difference of the plane of a vein, from horizontal or vertical. The Americans take the angle from the horizontal, the Cornish from the vertical.

Halter. A leather or rope passed over the head and around the nose of an animal, so that it may be secured to anything when not travelling.

Halvans. **Halvanners.** The first castaways of gangue with a little ore. The workers of such halvans for their minerals.

Hammer. Small and large: the former is used with one hand and is well known, the latter is applied to the boring chisel in drilling holes for blasting, and is also called mallet by Cornishmen. See single and double hand drilling, Volume II.

Hand-barrow. A wheel-less long box with handles each end, much used in Cornwall by the buxom Bal maidens for carrying ore to pile.

Handle. **Sledge-handle.** **Hammer-handle.** **Pick-handle.** **Shovel-handle**, &c. The Cornish miners more frequently say, "Hilt."

Hand-saw. A common saw, as used by *one* hand.

Hardness. Comparative hardness of minerals; of value in discrimination. See page 213.

Haul; Hauling. Hoist; Hoisting. Cornish and American expressions for the act of raising rock, &c., from the mines.

Hawser. A strong and tightly twisted hempen rope.

Header. A rock that heads off and delays progress. An upper piece of supporting timber. A blast hole at or above the head.

Heave. The shifting sliding or throwing of a seam, vein or lead; up, down or sideways upon the smooth face of a cross course, &c.

Hemp. The strong fibrous vegetable skin or bark, of which ropes are made.

Hexagonal. Six sided, like the naturally crystallized form of quartz.

Hilt. The name used by Cornish miners for handle; as pick hilt, shovel hilt, &c. See Handle.

Hitches. Steps cut in the rock or vein for holding stay beams, bearers or sticks of timber, &c., for various purposes.

Hobble. A short span of cord, leather or iron, placed cross-wise on a horse's fore legs to prevent straying.

Hod. A V-shaped trough with a long handle, used for carrying brick, mortar, &c., to masons.

Hoisting-engine. Cornish "Fire-whim." A steam power appliance for hoisting rock, &c., from mines. See Volume II.

Holt. An appropriate and practical Cornish abbreviation for hold fast or stop where you are.

Hone. Set-stone. A fretting stone for sharpening fine edge-tools.

Horn. A piece of bullock's horn about eight inches in length, cut boat shape, for miniature concentrations by water. Much used by mill-men for various examinations of powdered rock, &c.

Horn-saddle. The Mexican saddle which rises in front to a horn, or neck and flat head, shape; for carrying conveniences, lashing, &c.

Horn-silver. The common name for chloride of silver, because it has a horn-like surface.

Horse. A long convexed sided portion of foreign rock completely enclosed in the quartz or other matrix of the vein. A real horse is always composed of a different kind of rock to both the enclosing vein and its immediately surrounding country. Also a mechanical support for anything.

Horse-whim. An appliance for hoisting rock from mines. See page 151.

Hose. A strong flexible pipe, made of canvas, leather, rubber, &c., and used for the conveyance of water under pressure, to any particular point.

House-lift. A pump for supplying steam engine boilers with water. Generally fixed to receive its water from the adit level, where all surplus water runs away.

H-piece. An H-shaped Siamese-twin-pipe with four flanches and seats for receiving the upper and lower valves of the Cornish plunger pump.

Hub. The central box or nave of a wheel, which loosely thimbles the axle and securely receives the diverging spokes.

Huel. Wheal. Meant simply mine in ancient times, and is still used in Cornwall; as Wheal Towan, &c. See Bal.

Hulking-course. A soft gouging course beside the vein.

Hull. Gone to Hull. The somewhat sly slang phrase amongst Cornish miners for one who has *stolen a bed-rock sleep* during working hours.

Hurdy-gurdy. A bucket wheel that receives power from the percussion of swiftly travelling water.

Hydrant. A properly fixed, screw-stopped pipe; from which water may be readily drawn at short notice.

Hydrated. Any substance containing constitutional water; as the hydrated oxide of iron; burnt lime being the reverse (or anhydrous) until hydrated or slacked with water.

Hydraulics. The scientific and practical facts collected by many eminent men, upon the various modes of power and effective force of water.

Hydraulic-cement. The mixture of lime, magnesia, alumina and silica that solidifies beneath water.

Hydraulic-pumping-engine. Water power pumping machine. See Phillips's (as erected at the Great Onslow Consols Mine, Cornwall), Vol. II.

Hydraulic mining. The system of mining heavy banks of auriferous gravel by the penetrating and disintegrating force of small streams of quick travelling water, as first applied by Mr. Edward Mattison, in California. See page 61; also Hydraulic Nozzle.

Hydraulic-nozzle. The discharging nozzle for water from under great pressure in pipes, meaning the whole apparatus for changing the direction by hand or by deflection of its own water power, as well as the discharge through nozzles varying from two to ten inches in diameter.

Hydrochloric acid. Hydrogen and chlorine combined.

Hydrogen. The lightest of all known gases. Oxide of hydrogen is our common drinking water. Hydrogen is also a metal. See foot note page 30.

Hydrometer. An instrument for ascertaining the densities or specific gravities of liquids by the depth of floatation, as read on its graduated column.

Imbedded. Mineral pockets or veins, enclosed in rocks, are said to be imbedded.

Inclination. Dip. Underlie. Angle of incline; as the vein dips 48° from the horizontal line. Cornish miners take from the vertical.

Incrusted. When the surface is covered by some other deposit.

Interlacing. When threads or ribbons of one mineral cross those of another, and run hither and thither throughout the stone.

Interstratified. Lying between other stratifications; as a layer of greenstone between other layers of slate, &c.

Intervening-lode. The name I would substitute for Contact-lode; which see.

Iridescent. Applies to the variegated and gay colors upon the surface of minerals, as the peacock ores of copper, &c.

IRON. A magnetic metal. Symbol, Fe. Atomic weight, 27.

IRON PYRITES. See Alphabetical Chapter, page 233.

ISOLATED. Separated from; as the primitive rock occasionally emerges in distant *isolated* patches, &c.

ISOMORPHISM. Similarity of crystallized forms, sometimes from the fact of having filled the vacated cavities of other minerals.

ITACOLUMITE. Quartz in which mica has been variously imbedded. See page 235.

JACKET. An extra, surface, covering; as a steam jacket for the prevention of radiation.

JACK-KNIFE. A large, pocket, clasp-knife.

JACK-PLANE. A middle sized carpenters' plane for the rough shaping of boards.

JIG. To hand jig ores in a coarse sieve, when placed in and out of water during short reciprocating vertical jigs and intermittent horizontal twistings, so as to bring the lighter portions to the surface for being then scraped off. See jigging machine in the Second Volume.

JIGGING-MACHINES. Machines worked by short and quick strokes so that perforated plates or sieves may separate the better, coffee-berry sized, pieces of óre from the gangue, by intermittent motions of air or water. See Second Volume.

JOINTS. Frequent faces, or *joints* of fracture, in country rock. Joints of steam and water pipes.

JUMP. To take clandestine possession of another's claim.

JUMPER-DRILL. A long bar of iron, frequently having an enlarged knob weight in the middle, with one or two sharp drill shaped steel ends, and used by simply lifting and dropping, when drilling holes for blasting purposes. Much used by stone-cutters and surface miners.

JUNK. Short pieces of old and otherwise useless rope.

KEEL-WEDGE. A long iron wedge for driving in over the top of a pick "hilt," for securing greater firmness, when wrenching or levering out rocks.

KEEVE. KEEVER. A large wooden tub; used for the final concentration of tin oxide ore.

KEY. FEATHERING KEY. MILLWRIGHTS' KEY. An iron or steel bar of exactly suitable size and taper for filling the key-way, when driven, in axle and wheel, &c., for keying or securing tightly together. A feathering or millwrights' key is first firmly fixed in the shaft and then the wheel is either loosely or tightly slidden on and over it.

KEY-WAYS. Suitably true and corresponding spaces in hole and on axle for receiving the key, which none but skilled workmen can properly cut out and correctly finish.

KEY-WEDGE. The last and most important wedge driven in the handle of a hammer, pick, &c., and in many important places of wooden frame work.

KIBBLE. Cornish name for American bucket. It is, however, invariably made of iron plates riveted together, to a barrel shape; with a swing bow at top and a fixed half circular eye at bottom.

Kilogramme. **Kilogram.** One thousand grams and equal to 2.67951 pounds troy or 2.20485 lbs. avoirdupois, or 15,442.42 grains troy and avoirdupois.

King-post. An upright post over the middle of a beam or lever, for supporting strengthening bridles in double-triangle shape. Also used for attaching a rod for connecting power with distant work. See "Queen-post."

Kit. Any workman's really necessary travelling tools.

Kitting. A Cornish word for taking other men's ores, &c.

Knee-piece. **Knee-pipe.** A turned piece or pipe. Elbow piece or pipe. Also a strengthening piece near the foot.

Knocker. A surface lever striking on plates of iron, as moved by a line or chain extending all the way down important shafts. When struck thrice it means hoist or "wind up;" if twice, lower or "Streeke;" if say five times, stop engine; if six times, work engine, &c., or as indefinitely arranged for all purposes, after the decimated numerical manner of fire-engine bells.

Knocker-line. The signalling line or chain extending down the shaft.

Knuckle-joint. Two pieces of machinery or rods, connected by cross holes and pin, and affording free side motion.

Ladder. The Cornish ladder is always made with either round iron or oak steps, key-wedged in holes of the side runners; but the American has flat wooden steps, simply nailed in front of the runners.

Ladder-staves. The Cornish name for the steps of a ladder. See Ladder.

Ladder-way. The particular shaft, or part of a shaft, for the ladders; which should be in the safest and least used working gangway.

Lag. **Lagging.** The thick flat boards driven over or outside the regular frame-timbers of shafts and levels, for more safely securing the ground.

Lamb's-legs. Thin and narrow securing straps of iron, bolted around wood wearing pieces of pump rods, &c. Each piece has an eye or hole at one end and a screw at the other, so that one bolt serves as a gland for the other to connect the four into a square that can be mutually tightened by its own screws.

Lamellar distinct concretions. This means naturally separate crystals or plates.

Lamina. **Laminæ.** **Lamelliform.** Having an appearance of thin sheets, not naturally separate, but which may be forced apart.

Land. Grazing, agricultural or garden property; for which compensation must be paid to the landlord when it is destroyed.

Lander The man who receives and lands or deposits the rock at the surface, from the hoisted bucket.

Lander's-crook. **Lander's-pincers.** A hand crook or a double crook tongs, for upsetting the bucket of hoisted rock.

Landlord. The owner of the whole natural surface and ground.

Lantern. A portable shell with glass or horn sides for carrying a candle with greater certainty.

Lariat. A long cord of raw hide, leather or thong, with a loop at one end; which is thrown with astonishing precision by expert cattle herders and Mexican horsemen, when catching animals. See Lasso.

Lasso. Similar to Lariat. It requires an expert hero to lasso a grizzly bear.

Lateral. From the side; as lateral or side pressure has under my theory, crumpled, crushed and metamorphosed the mountainous regions. See Chapters I, II, III, &c.

Lava. The igneous rock that has been melted and forced up through volcanoes or vast fissures. See new theory of volcanic force, sixth heading, page 68.

Lbs. An abbreviation for avoirdupois pound; as 112 lbs. = an English hundred weight.

Leat. A small water ditch, as a mill-leat.

Leach. Leaching-process. Common names for lixiviation. See Lixiviating processes of the old masters in metallurgy, under Chemical Reductions, Volume II.

Lead. A ductile metal. Symbol, Pb. Atomic weight, 104.

Lead and Ledge (American), **Reef** (Australian), **Lode or Vein** (English. An ancient fissure now filled with mineral matter.

Lease. The long grant, of generally 21 years, from landlords to Cornish miners.

Leggins. Leather or rubber covers for the lower part of the leg; from foot to knee.

Level. A hole driven in the rock or vein for exploring or working purposes.

License. Take-note. Grant. The first grant of twelve months, as given to English miners by the landlord, for the purposes of examination and formation of working company; it promises a long lease, if desired within the year, other conditions being favorable.

Limb. Branch. Spur. An offsetting splinter from the main trunk of a vein.

Lime. A metallic oxide, earth. Symbol, Ca O. Atomic weight, 28.

Limestone. Carbonate of lime. Generally blue or gray, sometimes rusty yellow. See page 237.

Limited-liability. An English law for *pro rata* protection of stockholders, where the prospectus states the extent of future liability. Differing from the "Cost Book" system, which see.

Lining. Lining-timber. To line out work. The plank lining against frame sets.

Little Giant. The name given to a favorite and effective "Hydraulic Nozzle" for gravel disintegration. See Volume II.

Little-Wonder—Self-Calculating Sample and Button Weigher. See Phillips's at page 202.

Lixiviating. The operations for the extraction of soluble substances by water after certain changes produced by roasting, &c. See the processes of the old masters of metallurgy, Volume II.

Location. The putting up columns to bound a claim upon a vein. The site of a mineral claim, &c.

Long-Tom. A long wooden sluice for washing auriferous gravel to extract its gold. See Second Volume.

Lock. Lift-lock. A short basin in a river or canal, with gates at each end, for raising or lowering barges, &c.

Lock-weir. A convenient dam, &c., at the head of a lock to let water down through appropriate gates.

Load-stone. Lode-stone. The first is magnetic iron ore, so naturally charged or loaded with magnetism, that it is not only magnetic, but swings north and south, having primitive and negative poles, of its own. The second simply means lode-stone or *stone from veins* and not country rock.

Lode. Ledge. Reef. Vein. Lode is the Cornish name for a mineral vein. See Lead and Ledge.

Lord. The proprietor of the surface and its underground minerals (English).

Lord's-dues. A certain portion of the whole mineral's proceeds as agreed upon under the terms of the lease; generally one-eighteenth.

Low-grade. Low-grade rock. Not rich in mineral. Unprofitable.

Lumber. Timber cut to various sizes and shapes, for carpenter's purposes. (U. S. American, Canadian and British Columbian).

Lute. Luted. Luting. An adhesive clay, for resisting the action of fire; and used either to protect any iron vessel from too strong heat or for securing air or gas tight joints, in similar manner to engineers' flanch joints.

Machea. A leather covering that slips loosely over the saddle and down the sides of the animal.

Magnesia. A metallic oxide, earth. Symbol, $Mg\,O$. Atomic weight, 21.

Magnesium. A metal of difficult reduction. Symbol, Mg. Atomic weight, 13.

Magnet. Horse-shoe Magnet. A bar of steel magnetized.

Magnetic. Anything that turns towards the pole or is attracted to a magnetized substance or attracts the needle of a magnetic compass; as cobalt, iron and nickel.

Malleability. Any metal that can be extended by drawing, hammering or rolling, without fracture.

Mallet. The Cornish name for the double-hand hammer used for striking the borer in drilling holes for blasting.

Man-engine. A machine to which one or two reciprocating rods are attached with their suitable stages, for raising and lowering miners in deep mines. See Volume II.

Manganesium. A metal of difficult reduction. Symbol, Mn. Atomic weight, 28.

Manhole. An especial hole for just allowing a man to pass; as the man-hole of a steam boiler, or that in a ladder-stage, platform, &c.

Map. The lines of important objects, &c., as laid out upon paper for con[illegible]nt reference.

Mark. **The mark.** The agent's drill-hole or other mark on the side of a level, at the extent of the last ground excavated. It is a sad slur for any miner who has been known to *move* the mark.

Marl. **Growan.** A soft decomposed rusty feldspathic rock.

Marlin-spike. A sharp-pointed and gradually tapered round iron, much used in splicing ropes.

Massive. Forming in mass, not crystallized.

Materials. Such general goods as mines require.

Matrix. Gangue means all the associated waste rocks, but matrix should only include such as also aided in formation.

Matte. The product of the first incomplete reduction of an ore; as "Copper matte," where the sulphur is but partially volatilized and furnace *concentration* was the *sole* object.

Mattock. A, double or single, flat-pointed pick; Cornish "Biddix."

Maul. **Mall.** A heavy wooden hammer, bound with strengthening iron ferrules at the ends.

McAdamized. Roads made, after the fashion of McAdam, with small stones, which, under the pressure of the wheels, gradually settle into a firm and compact road.

Mercury. **Quicksilver.** A fluid metal. Symbol, Hg. Atomic weight, 100. See Amalgamation.

Mexican Saddle. A general purpose saddle, having a flat topped horn in front for holding the bridle, picket rope, rifle strap, "cantenas, &c., with "anqueras" apron and skin hangers in the rear, and fitted with buckskin strings for fastening saddle-bags, blankets, &c. Also, having protecting "bastos" beneath the saddle, "sudaderoes" down beside the stirrup leather, and "tapaderoes" in front to screen the toes from brushwood. The best saddle possible for prospectors and stock men.

Mica. The thin, fish-scale-like, elastic mineral of true granite. See pages 21 and 227.

Mill. **Battery.** **Quartz Mill.** **Stamps.** The large pestles and mortars as worked by water or steam power for crushing and amalgamating ores. Properly speaking a *mill* has also grinding and amalgamating pans attached, but the others are complete without them.

Mill. An underground reservoir of ore from which it may be let out by a lever-gate when required, to fill cars, &c.

Milligramme. **Milligram.** The one-thousandth part of a gram.

Miner. An underground workman, skilled in excavating rock, &c.

Miners' Safety Lamp. A small lantern so enclosed with fine wire gauze that although the foul air may pass in and burn a warning, the flame will not pass through and cannot ignite the outside explosive gas of coal mines. Invented by the Cornish chemist and philosopher, Sir Humphrey Davy.

Miners' Union. A provident society for mutual benefit and protection.

Mining-engineer. A man having more or less knowledge and experience in all of the many departments of mining. See Education of a *Mining Engineer*, Chapter I, Volume II.

Mining-school. School of Mines. An especial institution for teaching the rudimental requirements for a Mining Engineer. The first Mining School in Cornwall was started and superintended by my brother, J Phillips, about 40 years since, at the mining town of Tuckingmill. He has more recently superintended the Government School of Mines at Ballaarat, South Australia.

Mirage. A deception caused by rarified air in lines of vision near the surface of extensive plains or flats; such as unreal water, trees, rocks, &c.

Molybdenum. A rare metal of difficult reduction. Symbol, Mo. Atomic weight, 48.

Mortar. The vessel in which ore is put for being pulverized by pestle, "head" or "shoe." As those of the large battery and the laboratory.

Mother-lode. The principal vein, amongst others, of any region; as the mother lode of Californian gold mines.

Mould. An iron shell for casting metals into brick-shape.

Moyle. A drifting iron with sharp steel point for being driven into clefts when levering off rocks.

Muffle. The thin clay oven which is placed through an assaying furnace for cupelling gold and silver. See page 283.

Muller. The upper grinding iron or rubbing shoe of an amalgamating pan, &c.

Mustang. The native horse of Mexico and the Pacific States. A valuable animal, easily fed for great endurance. See page 124.

Nail. A sharp-pointed small-headed metallic spike for securing timbers in proper positions when building wooden articles.

Native-metal. When found in natural metallic state; as platinum is always found in native metallic condition. The native gold of California; the native copper of Lake Superior, &c.

Nickel. A magnetic, white metal. Symbol, Ni. Atomic weight, 29.5.

Nip. Hard-nip. Nipping Chain. To squeeze and retain. In a tight place, as the teamster said, when the short nip of the hill brought him to a dead stand. The act of holding the main rope of a winch by a short chain, whilst moving the rope across the barrel for another hoist, when lifting heavy weights.

Nipple. Nipple-piece. Nipple-pin. A projecting pin supported only at one end. A suitable piece with the nipple firmly riveted or screwed thereto.

Nitrate. Nitric-acid chemically united with a base, &c.

Nitrogen. A gas. Symbol, N. Atomic weight, 14. This gas and oxygen compose the air we breathe; but, with larger quantities of oxygen, nitrous and nitric acids are formed.

ITRIC ACID. Nitrogen and oxygen. Symbol, when anhydrous, $N\,O^5$. Atomic weight, 54. It absorbs water from the air and even thus becomes hydrated to $H\,O,\ N\,O^5$ (or $H,\ N\,O^6$) with an atomic weight of 63 (or $1 + 14 + 48 = 63$). See "Equivalent numbers."

ODULAR. BLISTERED ORE. KIDNEY ORE. When ores are of a blistered appearance or kidney shape, they are scientifically called "nodular."

OZZLE. The front nose-piece of a bellows or blast-pipe, to a furnace.

UGGET. A lump of gold, or other native metal. Applied to any size above dust.

NUGGIES. (Cornish.) Spirit Miners. An exploded superstition of the past; or the notion that spirits were encouraging them forward by making the sounds of mining before breast. Now spoken in joke but still regarded as a good sign because produced by water droppings in vughs or caverns.

NUT. The outer, and corresponding, portion of a screw; as screw and tightening nut.

OAKUM. The tarry hemp as picked and spread from old junk rope.

OIL CAN. OILER. A convenient conical vessel for oil, with a suitable handle and spout. One who attends to oiling the various parts of machinery.

OPAKE. Not clear. Not transparent.

ORES. The marketable and useful portions of mineral veins.

OVER-BURDEN. The covering incumbrance of rock, gravel, earth, &c., that must be removed, before really effective work, can be performed.

OWNERS' ACCOUNT. See "Account-day." Also, when working at per day, and not on any kind of contract.

OXIDE. The chemical combination of oxygen with a base, &c.

OXYGEN. Symbol, O. Atomic weight, 8. The gas that we extract from the air in breathing; and which also forms part of many acids, nearly half the weight of solid bed-rocks, and, when united with hydrogen, water. See "Hydrogen," and page 22.

PACK-ANIMAL. A beast of burthen; and necessarily much used in rough and mountainous, roadless countries; for packing provisions, minerals, &c.

PACK-SADDLE. An easily fitting pad with suitably light frame for attaching and securing the load.

PACK-NEEDLE. A large needle with a slightly turned point for sewing the seams of packing sacks.

PACK-THREAD. A strong twine-like thread for sewing large sacks.

PALEOZOIC. Belonging to the first rocks with fossils of animals and to the older divisions of geological time; which includes the Silurian, Devonian and Carboniferous ages.

PALM. A piece of stout leather just filling the palm of the hand and secured by a loop to the thumb, with a flat indented plate for forcing the needle.

PALM-NEEDLE. A straight triangular-shape needle used for sewing canvas.

Pan. Prospector's pan. To pan out, or it pans out well. A thin wrought-iron pan, 16 inches across the rim and 10 inches at the bottom; used in testing for gold, by water.

Pan-treatment. Milled on the large scale, by being thoroughly stirred and ground in pans for several hours with mercury, and then after amalgamation, settled, by slower motion, in still larger pans, with much more water. See many different pans at the end of Volume II.

Pass. A convenient hole for throwing down ore, or passage of men from one level to another. A mountain pass.

Pass-into. When minerals blend from one into another without sudden perceptible change. As flint passing into calcedony, &c.

Pasty. A convenient and portable food much used by Cornish miners. Made by baking meat with potatoes, turnips or onions, well seasoned and neatly enclosed in a shell of pastry. A savory and substantial meal.

Pay-day. The appointed day for paying wages and small amounts.

Pay-roll. A list of each man's amount for pay and receipt.

Penny. The one-twelfth of an English shilling. Abbreviation or symbol, *d.*

Pentice. A few pieces of timber laid lennie-roof-like over men's heads, to screen them from the hoisting bucket, falling rocks, &c., when working in the bottom of the shaft or other dangerous places.

Per. Per-oxide, Per-chloride, &c. To the utmost possible degree.

Pestle. A metal hand-rod for pounding minerals, &c., to powder.

Peter. Petered. Petering. Fail, failed, failing. As the ore will soon fail in No. 1 winze, has already failed in No. 2 rise, and the whole mine is rapidly failing.

Pick. A double-handed sharp-pointed instrument, with a wooden cross handle, for digging or excavating. See "Poll-pick."

Picker. A small sharp-pointed tool, for gouging beside the vein or between rocks, when held in the hand and struck with a hammer.

Picket-rope. The long small rope for holding an animal to a stake in the ground or to a bush or tree, to limit his travel when feeding.

Pincers. Landing-pincers. See "Landing-crook.

Pinion wheel. The smaller of two, cog-wheels.

Pipe-clay. An adhesive fine clay; much used by Cornish miners for candlesticks as when it is just properly moistened it becomes sufficiently putty-like to not only surround and hold the candle, but it may be also used for sticking it upon the hat or against the rock, when walking or working.

Piping. The expression used by hydraulic miners when undercutting and washing away banks of gravel, &c., before the water nozzle.

Pit. The shaft and workings of a coal mine, are often so called.

Pitman. An underground *mechanical* miner; and a most important officer.

Pitman's house. A surface workshop for the Pitman's sole use.

Pitman. A narrow side seam of clay, which will but just serve for a let-go during blasting. (West Cornwall.)

Pit-saw. See "Whip-saw."

Placer-mining. Surface mining for gold where there is but little alluvial debris.

Plane. **Plane-surface.** A true sheet surface; as ice in a pond, &c.

Plane-table. A very useful and cheap instrument for surface surveying; it has sights and a graduated ruler that lines distances across the centre with a lead pencil,as the sights are taken; so that all objects may also be positioned by measurement and then laid down upon several successive papers, when placed on its own round table, and transferred or traced, at any convenient time,,upon the office map.

Plastic. Not set to solid condition. Free for motion. See Chapters I, II, III, &c., where it is suggested that immense lateral pressure has caused and is still causing, plasticity, igneous action, metamorphism, &c.

Plat. **Tip-plat.** A receptacle for rock, ore, &c., as especially excavated for the purpose. When cut just enough below a level or railway for the cars and barrows to tip their contents directly into the hoisting buckets or skips, it is called a Tip flat.

Platinum. A grayish white metal, infusible by ordinary means; insoluble in any single acid, but soluble by released chlorine in a mixture of nitric and hydrochloric acids. Symbol, Pt. Atomic weight, 99.

Plateau. A plat or table of land, or rock formation.

Plication. Plying on, or folding of numerous layers; as the strata were much plicated in the exposed cutting.

Plumose. Feather-like.

Plunger-pole. **Plunger-pump.** The Cornish force-pump for deep mines; an important invention. See Volume II.

Plunger-pole stocking. The pole or ram is a simple cylindrical shell, and after the wooden stock is carefully sized down to fit snugly, it is driven in by a battering ram, and lastly wedged water-tight at the pole end, the other end forming the bottom piece for the pump-rod.

Pneumatic engine power. See "Air-engine," and Volume II.

Pocket-compass. A small circular disk, graduated either into points or degrees, with a magnetic needle swinging on a central sharp point, and enclosed in a suitably compact box.

Poker. Used in many ways by the Engineer and Assayer in fire operations; and by miners, as a poker or picker, in digging out side freedom before blasting holes charged with powder.

Poll-pick. A long pick-shaped point at one end and a short flat "poll," or hammer, at the other end.

Pool. A pool of water. As an especial pool to pump from, for better convenience below any level.

Poppet-heads. Cornish for derrick head or hoisting gear over a shaft.

Porphyry. Compact feldspar, spotted with differently colored crystals of feldspar. Feldspar is a silicate of potash and alumina; silicic acid 64.2, potash 16.95, and alumina 18.4. See page 21.

Potash. Potassa. Oxide of potassium. One of the alkalies.

Potassium. A metal lighter than water, of difficult reduction and very free oxidation, to alkaline reaction. Symbol, K. Atomic weight, 39.

Pot-ground. Such as will barely allow a level to be driven even with timber in advance.

Pounds. English money as abbreviated or symboled by £, as £, s., d.; also pounds weight, by lbs. See "Shilling," and "Penny."

Powder-house. A small and safe round house for holding powder; generally built in some distant and secure spot.

Preventive-brace or stay. A side diagonal rope, chain, or stick of timber, to prevent any erect object from falling.

Prian. A soft and soapy white clay; sometimes found within the joints and seams of quartz veins. A favorable sign for mineral.

Prill. An extraordinarily rich stone of ore.

Primitive-rock. The earliest formation; as granite. See page 21.

Produce. The assay percentage of an ore. See Standard and produce valuation of copper, page 395.

Prong. The forked end of the bucket pump-rod for attachment to the travelling valve and seat. See Volume II.

Prospect. Prospecting. A good or bad showing or prospect, after a suitable test. Exploring and examining with intention to locate.

Prot. Proto. One equivalent of oxygen, or chlorine, &c., with a base; as the protoxide of copper, the protochloride of tin, &c.

Protuberance. A spur-like or warty projecting piece.

Pseudomorphous. Not its true form. A pseudomorphous crystal has been formed, either by gradual substitution, or immediately filling a previously vacated cavity of another mineral's form of crystallization.

Pudding-stone. A cementation of mud and *rounded* gravel into rock; differing somewhat from conglomerates which include all *forms* of debris.

Pulp. The, slightly wet, pulverized rock from a battery.

Pulverize. To break or grind to powder.

Pulverulent. In powdered condition. When the particles of a mineral are small and cohere but slightly.

Pump-ring. An iron flat ring, which, when lapped with tarred baize or "engine shag," secures the connecting joints of water columns.

Pump-rod. Main pump-rod. The rod which connects the surface steam engine to the shaft pumps. The Cornish "main rods" are all of wood and vary in size from six inches to 20 inches square, and from 40 feet to upwards of 100 feet in length, and when attached by iron strapping plates they work to a depth of more than 2,000 feet. See Second Volume.

Puppy-lift. A smaller pump than the main.

Pyrometer. An instrument for measuring high degrees of heat by an external scale and lever, connected to an internal platinum wire, that, by passing through the fire, expands and contracts according to the degree of heat.

Quarry. An open cut or surface excavation; for obtaining building stone, roofing slate, &c.

Quartz. Silica. Oxide of silicium. See Alphabetical Chapter, page 249.

Quartzose. Siliceous. Partially composed of quartz.

Queen-post. The strengthening post beneath a "bob," beam, or lever. Preferably used for attaching horizontal pumping rods. See "King-post," and Second Volume.

Quill. See "Rush," and "Safety-fuze."

Radiated. Proceeding from a centre. Divergent crystals.

Raff. The coarse ore after the first crushing by Cornish rolls.

Raff-wheel. A revolving wheel with side buckets for elevating the "raff," (as it falls from the end of the diagonally placed cylindrical sieve) for a repetition of crushing to finer condition. See Cornish crusher, Volume II.

Rails. Long iron bars forming a roadway for the wheels of cars or tram wagons.

Rake. Fine-rake. Frame-rake. Tin dressing-rake. A small and plain, or toothed sheet, of iron; attached to a suitable handle, and used for moving and stirring fires, ores, &c.

Ram. To butt against with power; as attained by pressure, or speed and momentum.

Ram-battering. A long and heavy pole or bar hung to one or more pendulous rods, and swung against any object, for utility or destruction; as for the battering of doors, walls, &c., in ancient warfare, or for stocking a pole, &c. See "Plunger-pole stocking."

Ram-hydraulic. A slow travelling but immensely powerful ram fixed in a water-tight stuffing-box, and forced upward by a smaller pump under leverage. Its *theoretical* power is unlimited, being governed by the vast difference in area, &c., of the large and small rams.

Range. Stock-range, &c. Run or range of mountains. A natural run or range of country where animals may feed and fatten. See "Chute," &c., as regards its proposed use for "*Range of ore*" in veins.

Rasp. A coarsely indented file for shaping wood, &c.

Raw. Raw-sample. Raw-ore. Not roasted or calcined.

Raw-hide. Undressed or natural hide. Not tanned.

Reata. A long flexible rope mostly made of intimately woven raw-hide; as used for lariat or lasso.

Reduced. When a metal is, by some means, freed from its chemical associate, it is thereby reduced to metal.

Reduction. Any action or process that frees or extracts and separates metals from ores; as smelting, amalgamating, &c. See Vol. II.

Reef. **Quartz-reef.** Australian, for a gold-bearing lode. See "Lead and ledge."

Refining. The extraction of pure gold and silver from the base metals. See Volume II.

Refractory. Stubborn and difficult of reduction to metallic or commercial form.

Refuse. The waste or worthless rock.

Regulus. The impure metallic button obtained in the Cornish copper assay, next before the last operation, of refining the button to purity. Sometimes improperly applied for matte.

Reniform. In the shape of a kidney; as kidney iron ore, &c.

Report. A written professional statement from Manager, Superintendent, or Expert, after proper examination.

Reserve. Mineral already opened up by shafts, winzes, or levels; which may be broken, at short notice, for any emergency.

Reservoir. An artificially built, dammed, or excavated space, for holding a reserve of water.

Resue. To lay open a rich section of a vein by excavating on one side of the ore, so that it may be more easily taken out, without waste.

Retort. **Retorting.** A long iron vessel with a closely luted door, placed in a fire for heating amalgam, so as to drive off the mercury in fumes by an outlet pipe into water, for collection by condensation. See Volume II.

Returns. **Returning-charges.** Money as obtained after reduction, from the buyers of ores. For returning charges, see page 395.

Rich. Ore in very profitable condition, in any mining property; as struck it rich.

Riddle. A wooden frame provided with fixed bars of iron placed at proper distances, for sifting mortar, &c., when thrown against its sloping surface.

Rider. One who rides, anything that rides, as a rider or movable weight upon the beam of a balance. See "Little Wonder," page 202.

Riffles. Cross pieces in the bottom of a long sluice for retaining gold.

Rifle. A gun with a rifled or very coarse screw-grooved barrel for twisting the bullet in its flight, so as to self-correct any error from the true course.

Rifle-strap. A strap for swinging the rifle to the person, or saddle, when travelling.

Rill. **Rill of the pile.** The coarser ore at the outer edge of the pile.

Rim. The, more or less elevated, margin, of a basin-like rock formation.

Rip-saw. A hand saw with slightly pitched coarse teeth, used for cutting wood by way of its length.

Rise. To break rock over head, or upwards; for a stope, shaft or winze.

River-mining. Digging for and washing out gold, &c., from the gravel of rivers.

Roasting. Driving away the volatile elements of an ore by fire.

Rock-breaker. A machine for breaking rock; by crushing between its slowly travelling and immensely powerful jaws, &c. See Blake's, in Volume II.

Rocker. A long sluice-box for washing away gravel, &c., from gold, by cradle-like rocking. See "Cradle."

Rod. Main pumping-rod. Flat-rod. Side-rod. By-rod, &c. A means for connecting and transmitting power from any engine to the exact place where the work has to be done.

Rolling-ground. When the surface is much varied by many small hills and valleys.

Rope. Large and long twisted cords for hoisting, &c.; as hemp rope, wire rope, &c.

Rotary-engine. An engine that effects continuous circular motion of some or all of its own parts and those of the machinery driven. Not reciprocating.

Rotten-ripe-ore. Ore of a full grown or ripe quality and appearance; so that any change, would lessen its value. A good sign for abundance.

Rotten-stone. Tripoli. A soft and "rotten" pulverulent stone much used for cleaning and polishing metals.

Rubble. Coarse rock.

Rule. A measure; as a one-foot or two-feet rule.

Rules. The Cornish Superintendents have either written or printed rules, so that miners may not commit themselves, and be fined or discharged.

Run. A run of. rock or ground means, that it has given way and run down; as the shaft or mine has run together. Also a run or chute of ore.

Rush. One of the means used for blasting before the invention of the "safety-fuze," by simply filling a common stalk of rush with slow-powder, and then igniting it like the safety-fuze. See "Safety-fuze."

Rusty. Stained by iron oxide, or rust.

Rut. A small gorge or channel in the ground.

Sack. A canvas bag for holding and shipping ores, &c.

Saddle. A leather seat for a horseman. Also, a seat or stool for keeping rails, &c., in place. See "Mexican Saddle."

Saddle-blanket. Saddle-cloth. A cushion beneath the saddle.

Saddle-bags. Bags attached to a saddle for travelling convenience.

Safety-cage. A cage for hoisting and lowering miners, so made that even if the rope or chain should break it will not fall. See "Safety-catch."

Safety-catch. A double bow or lever catch with an underlying spring, which, immediately the rope or chain breaks, will counteract and stop or catch the cage, by a lateral jam, and prevent its falling.

Safety-fuze. A small twisted tarry cord with slow-burning powder in the centre; used for igniting powder when blasting rock: first invented and patented by a Cornishman named Bickford; it has been the means of saving many lives and limbs. Before this, quills, steel needles, and rushes were used, in connection with slow-burning matches.

Safety-valve. A valve, loaded by either lever and weight or spring, to a safe pressure, so as to release any surplus steam.

Sag. A depression of the summit's line of hill or mountain.

Sage-brush A dwarf, bushy tree, with sage-like leaf and very bitter taste; it grows upon the deserts and sandy flats of the interior.

Salary. A high-toned name for wages. The immense salaries for city officials, often prevent the success of mines, by thus wasting the money that should have been used for development.

Salting. Fraudulently enriching a sample by better ore.

Sample-taker. The officer who takes the average samples at the mines, for the Cornish buyers.

Sample-tryer. The Cornish name for assayer.

Sampling. Sampling-day. A mutually appointed day for taking the samples.

Saw. Cross cut-saw. Rip-saw. Hand-saw. Whip or pit-saw. See the different headings.

Sawing-house. Saw-pit. An especial house with a long pit, where logs are rolled to be cut into planks or boards, &c., by whip-saw.

Schist. Shist. Crystalline or metamorphic rocks having slaty structure; as mica schist, argillaceous schist, &c.

Schistic. Schistose. Schistous. Metamorphic and crystalline rocks, which may be split like slate.

Scorification. Scorifier. A shallow dish for assaying by the method of scorification. See page 281 and the left-hand vessel upon the front of the furnace, page 283.

Seating. The hollow and truly-faced ring upon which a valve tightly shuts.

Secondary rocks. Rocks situated above the primitive and below the tertiary formations. See page 26.

Sectile. Minerals which are sufficiently tough to cut smoothly without crumbling, breaking, or scattering before the knife.

Sedimentary rocks. Those formed from mud, &c., as drifted by winds or deposited from thick waters.

Segregated. Separated from others; and sometimes thus applied even should they recrystallize.

Self-calculation. See pages 202, 272, 291, 319, 422, &c.

Self-feeders. Mechanical appliances for feeding quartz batteries with rock. See Second Volume.

Selvage. An American term, of only occasional occurrence, (and probably instituted by some dry goods superintendent,) for the clay seam beside a vein. See "Clay," "Clay course," and "Alumina."

Semi-transparent. Partially or half clear; as when an object can be but indistinctly seen through a thin sheet of such a substance.

Serpentine. A hydrous sesqui-silicate of magnesia. The better, or precious kinds which polish to, variously colored, smooth and enduring surfaces, are much used for ornamental purposes. There is an extensive manuture of such articles at the town of Penzance, Cornwall.

Serrated. Of saw-tooth-like irregular contour; as some portions of the Sierra Nevada's summit are deeply serrated.

Sesqui. One and a half; as in the hydrous sesqui-silicate of magnesia, just described, where one and a half of silicic acid united with one of the other. See "Serpentine."

Set-hammer. The flat-faced hammer held upon hot iron by a blacksmith when shaping or smoothing a surface, by aid of his striker's sledge.

Set-screw. A screw, moving in or through *one* firmly fixed piece, so as to adjust or secure *another* piece, in any desired position.

Sett. Set. The Cornish name for the surface area of property as granted for mining purposes. To let or set contracts, &c.

Setting-day. The appointed day for letting contracts.

Shaft. A vertical or diagonal hole for the working-way of a mine.

Shaft-square. See Phillips's for irregular or round timber; in Volume II.

Shaft-screw. A large and powerful screw for especial use in shafts when lifting or lowering heavy pumps, &c. Its power-nut is laid on a washer across bearers, so that a chain may pass from the eye or bow, at the lower end of the screw, to the object beneath.

Shag. Engine-shag. Bal-shag. See "Baize."

Shaking-table. A table that is rapidly shaken by short motions during its water concentrations of ores. See Volume II.

Shale. A fine-grained rock with slate-like structure.

Shears. A large scissors for cutting sheet metals.

Shed. A roof, having but one sloped surface.

Sheers. The Cornish name for a high two-legged stand or hoisting derrick over a pumping shaft.

Shilling. The twentieth of an English pound sterling. Symbol, s. See "Pound." (£. s. d.)

Shoad-stones. Stray stones from the surface croppings of a vein or deposit of mineral, which frequently direct an experienced man to valuable mines.

Shoot. Shute. Chute. The *range* of mineral in a vein. See "Chute."

Shop. A house where tradesmen work, &c.

Shore. A studdle; an artificially placed supporting column; a thrusting stay.

Shot. Blast. The explosion, blast, or shot of the confined powder when excavating rock; as that blast boomed so much that it must have been greatly overcharged with powder.

Sierra. Spanish for a serrated mountain.

Sieve. A short cylinder with a fine, wire-gauze, bottom; used for sifting ores.

Sifted. When passed through a more or less fine sieve.

Silicium. The metallic base of quartz or silica; Symbol, Si. Atomic weight, 15.

Sills. Two strong shaft bearers fixed across engine shafts, and beside pumping rods, for the catch pieces to strike upon when at the limit of the out-door's stroke. Also, for trigging the rod. See Shaft Work in Volume II.

Silver. The whitest of metals. Symbol, Ag. Atomic weight, 108. See page 250.

Sizing. Assorting by hand, sifting, or water treatment; for grades of size.

Skip. The Cornish name for a long and smallish wagon used for hoisting rock from mines, it has either wheels or guiding blocks which work on connecting runners of iron or wood, extending the whole depth of the shaft. See illustrations of such in Volume II.

Slag. Slagging out, &c. The melted gangue from the furnace smelting and assaying of ores. Cleaning the furnace of slag.

Sledge. A heavy double-handed hammer.

Sleigh. Sled. A vehicle without wheels, and having double keel-runners instead; it is used for travelling or transferring ores, when the ground is covered with snow.

Slicken-slide. A slippery, corrugated face, in bed-rock or beside a vein, and sometimes within the vein itself, as if a sliding had produced this striation. See italics, page 148.

Slime. Slooge. Sludge. Slush. Pulp. The fine wet mud from a mill or drill hole, &c.

Slow-fuze. Slow-match. A fuze, match, or torch; so especially made as to burn its powder or other combustible very slowly.

Slugs. Half-roasted ore.

Smoothing plane. A small and short plane; used by carpenters for smoothing, or finishing their wood work.

Snow-shoes. Peculiar skates of much increased area, secured beneath the ordinary shoes, for travelling on snow. See page 125.

Soap-stone. A very soft and slippery steatitic fire-resisting stone.

Soapy-clay. See "Pipe-clay."

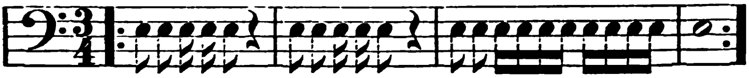
Sod. The surface covering of earth.

Sodium. A metal of difficult reduction, and so very light and free to oxidize that it floats upon the surface of water, and immediately oxidizes into soda. Symbol, Na. Atomic weight, 23. See page 252.

Sollar. A wooden platform across a shaft or other working; as it is advisable to *sollar over* any idle shaft or winze so as to ensure safety. Sometimes used beneath the surface for working convenience and safety.

Soot. Sooty. The carbonaceous black powder from imperfect combustion; hence a mineral may have a sooty or soot-like feel, tarnish, and appearance.

Sounding. An alarm or call amongst Cornish miners. When used at the surface, as within the first set of timbers of the shaft, it simply calls for an answer from the men who may be at work in or near to the shaft. If used in any part of the underground workings, it demands the serious attention of all within hearing, because the sounder may be in danger, or in great want of assistance. It may be compared to the beat of a drum, but it is performed by striking a hammer or sledge, upon the rock or a piece of timber, to the following notes:



Spale. Cornish, for a *public fine* when workmen break rules, &c.

Spall. To break large rocks with a sledge or cobbing hammer to suitable sizes for hand assortment.

Span. To fetter or tie the side legs of a horse together to prevent straying or trespassing.

Spanish-bit. A horse's mouth bit with an additional curbing lever to nip the tongue.

Spanish-windlass. A looped or double rope attached to two objects and then twisted by a cross-bar through the middle, which creates a power by shortening as it is tightly twisted.

Spanner. A wrench for tightening screws. (Cornish.)

Spar. A name for some white quartz-like stones; as quartz-spar, feldspar, calc-spar, heavy-spar, fluor-spar, &c.

Spathose. Spathous. Sparry. Of spar-like appearance; as spathose iron ore, &c.

Specific-gravity. Comparative degree of weight; as ascertained by first weighing in air, then in water, and dividing the first real weight by the difference. See page 213.

Specular. Sometimes applied to minerals which present smooth and bright reflecting surfaces to distinguish them from others, of the same metal, which do not.

Spell. Spur. Pass. Awhile. Short turn, or tiring round, at the work.

Spelter. A yellow, gold-like, fusible alloy, used for brazing or joining metals together.

Spew. A slight outpouring or evolution of minerals, caused by water or heat; as it is only a surface spew.

Spilling. Driving or sinking through soft and difficult ground, where peculiar lath timbers must be driven in advance beyond the regular sets.

Spirit-level. A truly shaped glass tube, so nearly filled with spirits of wine that a bubble of air shall move along the top, to centre and show when the instrument is level.

Spirit-miners. See "Nuggies."

Spoke. A radial bar of a wheel, fixed in and extending from hub to rim.

Spur. An off-setting pointed branch from a deposit, lode, or mountain. Angles, dips and spurs of a vein are claimable.

Spur-wheel. A comparatively small driving wheel.

Spur—Mexican. A horse spur for the boot heel, differing from the common spur by having a much larger, sharp-pointed, spur wheel.

Stack. A high chimney. To stack ore or cord-wood into piles.

Stain. A coloring of matrix or bed-rock, by minerals; as the stains of carbonate of copper, oxide of iron, &c.

Stalactites. Mineral formations of inverted-cones or icicle shapes, seen hanging from the roofs of caverns.

Stalagmites, Opposed to stalactites, by forming other dualistic cones with points upwards, from the dropping of mineral waters upon the bottoms of caverns.

Stampede. The hasty, heedless rushing of animals or men under sudden fright or undue excitement.

Stamps. The Cornish name for a battery of pestles.

Standard. The mint standard values of gold and silver thousandths' fine, as used for coinage. The standard for copper buyers. See page 395.

Staple. A U-shaped band with screwed ends for tightening two or more pieces together by staple and gland. Also, to drive into wood as a U-shaped, double-pointed nail.

Starve. When a pump is choked at the "Brass-holes" it is said to be starved.

Station. A plat or convenient resting place, in a shaft or level.

Stave. A ladder step, &c.

Stay. A side tie or attachment.

Steam-capstan. A steam power winch for hoisting and lowering heavy weights in engine shafts, &c. See Second Volume.

Steam-gauge. An apparatus for showing the pressure of steam in a steam boiler. An inverted syphon pipe with mercury and a stick of wood floating up and down a scale, is a simple and good indicator of pressure.

Steam-whistle. A whistle for the workmen when coming to and leaving work, or for signalling danger, &c.

Steel-needle. One of the instruments used for blasting before the invention of the safety-fuze.

Stellated. Crystallizing in forms like the rays of light from a star.

Stem. A day's work. (Cornish.)

Stick. A whole piece of timber, as it grew.

Stoping. Excavating the vein, either above or below a level, and endwise from a winze.

Storehouses. Where the requisite materials are kept.

Strapping-plate. Strong iron plates for connecting wooden pump-rods by transverse bolts and nuts.

Stratum. Strata. The stratified rock formations. Also applied to all rocks.

Streak. The color of a stone of mineral when scratched; as it streaks or scratches red, &c.

Streeke. A peculiarly penetrating, loud-sounding, and readily understood, Cornish word; for lower away.

Striated. Marked with parallel grooves or fine channels.

Strike. Find. To discover or cut profitable quantities of metal or mineral.

Studdle. Shore. A stiff piece of timber used as a support from beneath.

Sturt. (Cornish.) Probably from start. To open out richer ground than the contract or tribute equalled, and thus make an excess of wages, during the term.

Subsidence. A settling of rock or country. In my theory for mountains, the valleys or plains and ocean beds have, by settling faster than the mountains, made them appear as if elevated. See Chapters I, II and III.

Subsist. An advance from the owner to the Cornish miner as food money, when he has been unfortunate in his contract.

Sub-stratum. Underlying rock formation.

Subterranean. Beneath the surface, and within the rock itself.

Suction-pump. Not forcing but drawing, and getting its water by following a vacuum.

Sudaderos. A wide leather strap down the stirrup-belt, to protect the leg from being too severely rubbed.

Sulphate. Sulphuric-acid with a base, &c.

Sulphide. Sulphur with a metal. See Sulphuret.

Sulphite. Sulphurous-acid with a base, &c.

Sulphur. A yellow inflammable element. Symbol, S. Atomic weight, 16. See page 252.

Sulphuret. Sulphur united with a metal. Applied to natural mineral formations. Sulphide is applied to chemical and metallurgical compounds.

Sulphuret of Iron. The "Mundic" of the Cornish miners, where it is much mixed with other minerals in the shallow sections of lodes.

Sulphuric-acid. Sulphur 1 atom, oxygen 3 atoms. Symbol, $S\,O^3$, which will equal the atomic weight of 40. Hydrated sulphuric acid or $H\,O, S\,O^3$, or $H, S\,O^4$ will be 49.

Sulphurous-acid. Sulphur 1, oxygen 2. Symbol, $S\,O^2$. Atomic weight, 32.

Sump. The deepest part of a mine to which the water drains.

Super-imposed. Laid upon another formation.

Supernatant. Floating upon the surface of water; as metallic sodium, potassium, and the oils are supernatant.

Surcharged. Charged to its full capacity.

Surface-deposits. Those that are exposed and which can be mined from the surface.

Swab-stick. A small stick with a battered, brush-like, end; for taking the water out of blasting holes.

Swage. Bottom Swage. Top Swage. Shoes and dies of suitable forms for forging iron to certain shapes, when held in the bottom swage, and the top swage is struck down thereon with a sledge-hammer.

Swing-crane. A winch with a vertical axle and horizontal gallows-like outrunner or jib, for swinging the load to any point within its radius of area described.

Swing-pump. A shaft pump swung clear of the bottom and only fixed on bearers or hung under a shaft screw or pair of power-blocks for lowering at convenience, when sinking, &c.

Switch. A movable rail for turning cars, &c., from one track or pair of rails to another.

Sword-rod. An iron rod terminating with a thin perforated plate, for connection with a wood rod, by insertion and cross bolts.

Symbol. An abbreviation or short expression; as H for hydrogen.

Syphon. See "Syphon-pipe."

Syphon-pipe. A crooked or inverted ɿ shaped pipe for drawing off water, &c., by continuous suctional action and discharge.

Tabular. Flat surfaced and thin mineral crystals. Plane laminations.

Tackle. A long-barreled, double or single handled, hand windlass; placed across a shaft or winze, for hoisting rock, &c.

Tag. A distinguishing label or mark, attached to sack or box for direction, guidance, &c.

Tail-board. A movable board at the last end of a wagon or other working appliance.

Tailings. What passes away from reduction works after any systematic treatment.

Tail-race. The quick travelling water from any power, as it leaves after its work has been performed.

Take-note. See "License."

Talc. See page 253.

Talcose-slate. See Slate and Talc; also, page 252 and Chapters VII, VIII and IX of Section I.

Tally. To make agree; as in counting sacks of ore, &c., when the tenth passes, one counter cries tally with a loud voice, so that others may check an error.

Tamping. What is rammed into blasting holes above the charge of powder, to confine it down for more effectually rending the rock. It must be some small dirt which is free from silica or any other rock that will strike fire before the tamping bar.

Tamping-bar. To ensure safety, the tamping-bar for ramming in the dirt above the powder should not be of iron or steel, but copper or some metal that will not strike fire with quartz, &c.

Tap. A turn-cock, which may be stopped or opened at pleasure.

Tapaderos. The leathers in front of the stirrup for protecting the toes when riding through brush-wood, &c.

Taper-tap. Plug-tap. A steel screw, suitably grooved and sharpened for cutting out the internal screws in bolt nuts.

Task. A certain amount of work given by the "Boss" for a day's work.

Tax. A levy upon property. Assessors should be slow in taxing mines which are making assessments, because such losses benefit others.

Team. Horses and wagon.

Team-whip. Black-snake. A heavy leather whip of blacksnake-like form and appearance. A cruel caution to horses.

Telluride. Tellurium and a base.

Tempering. Warming steel tools to certain suitable heats and dipping them into cold water, so as to harden the sharp edges.

Tender-feet. The name given to eastern men by Colorado Indians, to distinguish them from men of California and the Pacific States, as they dislike, those they also call, Washington Americans, &c.

Tent. A portable canvas house, sometimes used when "camping out."

Tent-hook. A hook for securing the tent to the ground, &c.

Tepid. Slightly warm; as tepid mineral depositing waters. See my theory, for the formation of minerals, page 115.

Ter. Third or three of; as Tertiary formation, terchloride of, &c.

Tertiary-formation. Third formation of rocks; when the highest class of vertebrate animals, or mammals first appeared.

Tester. See page 162.

Test-lead. Granulated lead, made by shaking molten lead in a wood box until cold. It should be of the size of grains of sand and almost, if not quite free, from silver. Used in scorifying gold and silver, and in testing, by cupellation, for thousandths fine. See page 286.

Test-papers. Prepared bulbous papers for testing; as those of color for acids and alkalies, &c. See also Foot note, page 205.

Test-silver. Pure silver in thin sheets; used for adding to cupelled assay buttons of bullion, so that the ratio of silver may be sufficient for the effectual parting of the Au. and Ag. by nitric acid.

Test-tubes. Very thin glass tubes either open at one end for wet tests, or both ends as required for fire testings. See page 185.

Tether. See "Picket rope."

Theodolite. A small circular box with glass cover, wherein a magnetic needle swings on a sharp pivot. It is provided with horizontal and vertical sights and degrees so that all possible angles may be measured, when surveying mines, &c.

Ticketing. English periodical markets for the sale of ores. See page 395.

Timber-hitch. When the end of a rope is first passed around one or more boards of timber and then so twisted that the end loop shall encircle and slip the leading rope, whilst the twisted part securely jams itself upon one or more pieces of the lumber, and thus prevent their slipping.

Tin. A white metal. Symbol, Sn. Atomic weight, 59. See page 255.

Tin-dressing frame. An oblong square frame of slight declivity, having central end trunnions for occasional tipping, as the concentrated ore accumulates.

Token. A mutually understood mark or sign placed upon a kibble, bucket or skip of ore, when it is hoisted from, or lowered into a shaft, to acquaint the "Lander" or "Filler" of some important matter or change of work.

Toll. Toll-gate. A sad barrier to the traveller who has no money to pay his way.

Ton. The American ton, is 2,000 lbs.; for the English tons, see page 303.

Toughness. Those minerals of difficult fracture. Not brittle.

Tow. Short and useless coarse hemp used for wiping, &c.

Trail. Track. A narrow path mark; as that of Indians or wild animals.

Tram-way. A small and roughly constructed iron track for horse "tram-wagons" or cars.

Translucent. Partially transparent.

Transome. A heavy wooden bed or supporting piece.

Transparent. That which will not interrupt the sight; as glass.

Trap. A highly feldspathic, igneous rock.

Traveller-pulley. Traveller-carriage. Traveller-guide. Traveller-wheels. Appliances for carrying any rod or weight forward and backward, or up and down, by reciprocating motions.

Tray. Picking-tray. Washing-tray, &c. A small and convenient box for any purpose, as that for washing ores, &c.

Treadle. A foot-board and lever for working small power-machines by the foot.

Tree-nail. A wooden nail for securing planks or beams together; as the timbers of a ship.

Trend. To range or lie in any particular direction; as the mountains of Nevada State mostly trend north and south.

Trestle. Trestle-work. Any structure which is supported by, or mostly formed of, a net-work of timbers; as that of a railway or viaduct over a valley when supported by vertical sticks properly secured and stayed by horizontal runners and diagonal bars or studdles.

Tribute. A Cornish mode of contract, where miners take at, say six shillings, out of every pound's worth of mineral raised and sold.

Trig. To block or stop a wheel or any machinery; as to stop a Cornish pumping engine upstroke or "indoors," by placing a substantial trig of wood upon the "sills" and under the side catch pieces that are always attached to the rod, by strong "staples and glands." See "Sills."

Trilabite. An extinct shell-fish belonging to the Paleozoic era.

Trompe. A French water-blast, in which water falls through a pipe upon a flat plate and scatters into a wooden box, so as to carry air before the spray to outlet pipes for each. Used for ventilation, and forge fires.

Trough. A small tank for holding water, &c.; as a blacksmith's trough, a drinking trough for horses, &c.

Trowel. A small one-handed shovel used by masons, plasterers, and iron founders for smoothing mortar, plaster, casting-sand, moulds, &c.

Troy-weight. The system of weights by which gold, silver, and jewels are weighed. 480 grs. = 1 oz.; 12 oz. = 1 lb.; 4 gr. = 1 carat. 24 carats fine = pure gold.

Trying-plane. A long plane, used by carpenters for making straight work.

Tub. A half barrel used for various washing purposes, &c.

Tubercular. Having small knobs or tubercles.

Tubular. Hollow and cylindrical; like a sugar cane or pipe stem.

Tufa. A soft porous stone formed by water and lime, volcanic scoria, &c.

Tun. A liquid measure of 2 pipes, or 4 hogsheads, or 252 gallons.

Turbine. A quick-travelling water-wheel, impelled by a pressure of water upon curved blades. See Volume II.

Tutwork. Breaking ground, at per foot or fathom, &c. See "Tribute."

Twyere. Twier. Tweer. The portion of the blast pipe that enters the furnace. Sometimes also applied to the iron shell around the blast hole.

Tye. The Cornish name for a kind of ground sluice.

Tyre. The iron binding of a wagon wheel, &c.

Uliginous. Slimy. Muddy.

Unctuous. Soft, soapy, and grease-like.

Underground. Beneath the surface; down in a mine.

Upcast. A shaft through which air rises ,is called an upcast shaft.

Upheaved. When a seam or lode has been broken and one part shifted upward.

Upper-hole. A hole drilled in the upper part or back of a level.

Uplift. Upraise. To force upward.

Valuation of Bullion and Ores. At thousandth's fine and per ton. See pages 270, 272, 298, &c.

Valve. A metallic clack, opening for passage, and shutting water-tight.

Vaporization. The changing solids and liquids into gaseous conditions.

Variform. Having various forms.

Vat. A large wooden barrel sided tub, as used for chemical treatments, &c. Also, a stone or plastered tank over a furnace, for drying ores.

Vault. A large, artificial or natural, underground chamber.

V-bob. Fend-off-bob. Pull-back. A two-limbed bell-crank, secured with bridles for connecting with and turning pumping rods, &c., over and beyond angles in shafts. When this is done by a swing-rod or chain from the opposite side of a shaft it is called a Pull-back.

Vegetate. To crystallize, exude, or, in a manner, grow.

Vein. Lode. Ledge. Reef. A fissure of the rock filled with some matrix and more or less mineral. See Lead and Ledge and foot-note at page 97.

Veinous. Rock or matter from the vein, and not "Bed-rock" or "Country."

Ventilation. Circulation of air through workings, shafts and levels.

Ventilator. Some machine or suitable pipe, shaft, level, air sollar, or fire draught for producing a current of air or ventilation.

Vernier-scale. One scale moving upon another of different graduation for the closer reading of intermediate distances, of sight lines over degrees.

Vesicular. Full of cavities. Hollow.

Vessel. Applied to pitchers, bowls, cups, &c., of all sizes and shapes.

Vest-pocket-blow-pipe. See Phillips's, page 212.

Vial. A small bottle with an aperture to receive a cork.

Vice. Bench-vice. Hand-vice. Two strong iron jaws so hinged that they may be opened and closed by a powerful screw and lever, for gripping work during manufacture, &c. The hand-vise is held in the hand, and the bench-vise is firmly screwed to the bench.

Visual. Relating to the sight; as visual discrimination of minerals.

Vitreous. Glasslike; as the slags are sufficiently vitreous for good results.

Volatilize. To disperse solids or fluids into vapors or gases, by fire, &c.

Vugh. The Cornish name for a cavity or vault in bed-rock or vein; as a vughy lode is a good indication for free passage of water and mineral.

Wacke. A soft and earthy black, brown, or greenish gray basaltic rock.

Wad. Wadd. Hydrated oxide of manganese with various accidentals; as oxide of iron, alumina, lime, silica, and baryta.

Wagon. Tram-wagon. Car. A wheeled vehicle for carrying ore, &c.

Warty. Of a pimpled or wart-like appearance.

Washer. A flat disk with a round hole in the centre, used around bolts, to receive the tightening strain from screw-nuts.

Waste. Worthless castaway rock, &c.

Waste-gate. A hinged or sliding door for regulation of surplus water.

Waste-weir. An especially arranged embankment over or through which the water passes by way of waste-gates.

Watch. Shift. Core (Cornish). The time of labor. The miners of Cornwall work by either 6 or 8 hours' shifts, commencing at 6 in the morning and running through the 24 hours; as first core by day or last core by day, first core by night, &c.

Watchmen. Those who watch machinery, &c., on Sundays, &c.

Water. The product of combustion of oxygen and hydrogen gases. See pages 26, 27, 28, 29, 30, 31, and 32, for its many characteristics.

Water-bellows. An inverted air tank working over and in a cistern of water; and connected with suitable inlet and outlet pipes and valves. See Vol. II.

Water-constitutional. When chemically combined, as an elemental portion, of any substance. See Water, at page 256.

Water-course. Water-way. An artificial channel for passage of water.

Water-gate. See "Waste-gate."

Water-gauge. A tap or float for showing the height of water in boilers, &c.

Water-metre. A self-acting measure.

Water, Miners' Inch of. An orifice of one inch square under a head of six inches of pressure. Regulated by a sliding gate to any desired quantity.

Water-power. Machinery driven by impact pressure, or weight of water.

Water-privilege. Water-right. A right to have a certain quantity of water from any canal, ditch, or water-course.

Water-weight. The quantity of water in any ore or substance. Ascertained by drying say 100 grains at 212° and then noting loss of weight.

Water-wheel. Overshot. Undershot. A power wheel with buckets.

Waxy. Of wax-like softness.

Wear. A dam for water.

Wedge. A piece, tapering to a point, for tightening, lifting, &c.

Wee. The Scotch word for little. See Phillips's "Wee Pet" assaying machine, pages 171, 172, 307, 326, &c.

Weigh. Weighing. See page 298, &c.

Weigh-bridge. A heavy weigher with a table forming a part of the street or road, so that loaded wagons and carts may be driven thereon and the weight of the material known by subtraction of the vehicle's weight.

Whetstone. A granular quartzose stone used for sharpening edge-tools; as knives, reap-hooks, &c.

Whiffle-tree. Whipple-tree. The front cross-bar of a carriage to which the drawing ropes, leathers, chains or traces, are attached to the horses.

Whim. See page 151.

Whipsidary. Single and double. See page 150.

Whip-saw. Pit-saw. A long coarse-toothed saw with a fixed cross-handle at the top end, and a movable clutch boxed cross handle at the bottom or point, so that two men may work it for cutting logs, &c., lengthwise.

Whistle. Whistling. Cornish miners have a superstitious objection to *whistling underground.* In fact, they never do it, and will immediately stop strangers who may unconsciously start into such unbecoming hilarity, during the working hours of this dangerous business.

White-tin. The trade, or commercial, name for metallic tin. The concentrated ore of which, or oxide of tin, being called "Black tin." See page 402.

Will-o'-the-wisp. Jack-a-lantern. Ignis-fatuous. An uncertain and flitting, or intermittent and pale, phosphorescent light; supposed to be caused by the rapid decomposition of plants in moist or marshy positions. Many stories have also been related of its appearances over rich mineral lodes, even before they were known to exist, and of course such were considered favorable evidences for value, but if so it must have been from moist decomposition, therefore had nothing to do with mineral value, and only very few have seen them. Not yet noticed over U. S. veins.

WINCH. A strong power machine for hoisting heavy weights, &c., in which the power is obtained by a proportionate lessening of speed by tooth wheels, &c., in connection with ropes upon a barrel, &c.

WIND-BORE. The bottom pipe of any system of water pumps, which has suitable "Brass-holes" or perforations for suction of water or air.

WINDLASS. A long parallel wooden barrel for rope or chain, with a hook handle at one or both ends, for increasing hoisting power by hand labor.

WIND-MILL. A horizontal axle with vertical divergent arms and sails for obtaining power from the wind in elevated sites.

WIND-UP. HOIST AWAY. The practical order for raising anything to a higher position. Opposite to "Streeke," which see.

WING-DAM. A dam for water of a wing shape; as used for the temporary division of a river in the direction of its course; when extracting gold from the comparatively dry side.

WINZE. A shaft that does not start from the surface, but only extends from one level to, one or more, deeper levels.

WIRE-ROPE. Metallic wires twisted like hemp yarns into rope; used for stays, hoisting, &c. See Table of Comparative Strengths, in Volume II.

WOLFRAM. Tungstate of iron. See Tin, &c., in Alphabetical Chapter.

WORKING-BARREL. The truly bored long cylinder of a suction pump in which the bucket and its valve travels up and down when pumping water. See Bucket valve, and Volume II.

WORKINGS. The various underground holes or excavations of a mine; as the "*old mens'*" or *ancient miners'* workings, are often found in Cornwall.

WRENCH. A turnscrew, or pipe-twister.

WROUGHT-IRON. MALLEABLE-IRON. The tough iron that blacksmith's work into shape when hot; by hammering, welding, &c. Not cast iron.

YIELD. The quantity obtained, of the valuable mineral or metal sought.

YOKE. The neck collar as used for draught. Also so many *yoke* of oxen.

YOKES. A pair of iron clamps of a semi-circular shape, with a cross screw and nut at each end for tightening them around heavy pipes, &c., for attaching the ropes when hoisting or lowering into position, by power.

ZINC. A gray metal. Symbol, Zn. Atomic weight, 32. See page 256.

ZINC PROCESS. See Parke's Zinc process for desilverizing lead, in Volume II.

ZIRCONIUM. A rare metal. Symbol, Zr. Atomic weight, 22.5. See page 249.

ZONE. A comparatively long and narrow area of mineral ground or rock formation. Sometimes called belt.*

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*These technical expressions, have covered many more pages than I anticipated, but they are really necessary for the, unposted, reader's reference, and if any important words have been omitted in this hurried compilation, they shall be inserted in future editions.

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